Watershed Monitoring and Assessment Design Workbook

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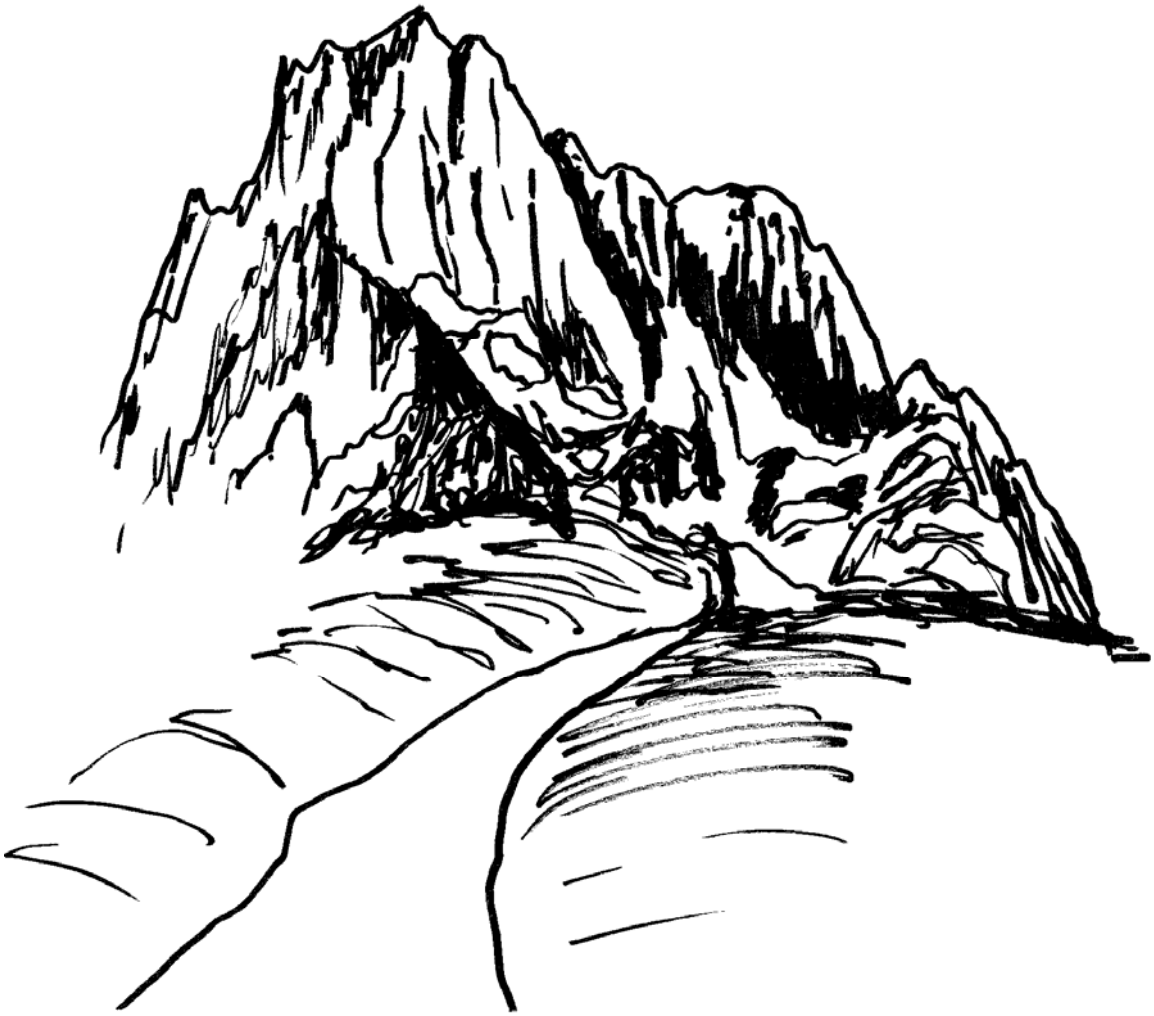


By Barb Horn and Geoff Dates

Funded by United States Environmental Protection Agency, Region VIII

Rocky Mountain Watershed Network Presents:

WATERSHED MONITORING AND ASSESSMENT DESIGN WORKBOOK

Written and Compiled By:

Barb Horn and Geoff Dates

Funded by:

United States Environmental Protection Agency, Region VIII

Illustrations by:

Pat Howard, Tim Shields (Phase 1, Step 5 Decision Tree), & Lera Main (cover sketch)

For More Information Contact:

Barb Horn at barb.horn@state.co.us or 970/382-6667, rmwn.org

With Special Thanks to:

River Network
Colorado Division of Wildlife
Rocky Mountain Watershed Membership
Tina Laidlaw
Peter Ismert
Steve Dickens
Angie Becker Kudelka
Kristy Miller
Brian Bromelow
Joshua Walton
Margaret McCoy

PHASE 3: INFORMATION DESIGN: Turn Data into Information

Step 12 – Data Summary and Analysis
Step 13 – Interpretation, Conclusions and Recommendations
Step 14 – Communication and Delivery
Step 15 – Management to Generate Information (Data Management Plan Part 2)

Introduction and Summary of Phase 3

At this point you have a vision, mission, desired set of outcomes, monitoring reasons, targeted data users or decision-makers, the needs of those data users and monitoring questions. You should also have a list of chosen indicators, methods, sites, frequency, and quality assurance, which was derived from the above planning process. Thus far, we have planned how we will collect data, numbers and results thus far, now we need to plan the important work of turning those results into information.

Numbers, data and results are generated by monitoring activities, but the numbers, data and results are not information. Information is the story we give the numbers, data and results. If someone picks up a piece of paper with data on it and says, "Oh, the dissolved oxygen levels are really low", they have just transformed the numbers on the sheet through their interpretation "filter" and made a conclusion, they created their story. The numbers were just numbers.

The data are the words in a story, the sentences, put together in a certain way tell a story. Put together in a different way tells another story. In the process of creating a story data are transforms into information through analyses, summaries, interpretation, findings, conclusions and recommendations we develop. We need to plan how we will conduct this transformation of data to information, when it is complete, we have a story, we have book. Get your agent and book a signing. This plan, to turn data into information to take to action, is called a **data pathway**, a planned data pathway is one that is measurable and can be evaluated. We all have experienced what we think are data pathways, and maybe, but are really data dead ends, because the pathways were not planned, agreed upon, connected perhaps to our outcomes, a purpose or an objective. The data might end up somewhere, but is that were it is suppose to, is it really used, how do you know? Only by designing and employing your data pathway will you know.

Phase 1 Step 6 had you complete and Information Blue Print – Data Pathway Fact Sheet as a tool to communicate the specifics of why each data point is generated, how it is generated. Phase 2 designed how the data would be generated, the level of quality necessary and how raw data will be managed and validated to be ready for the steps in Phase 3. Phase 3 is your plan to turn that raw data into information and deliver it.

The act of reporting the information, our story, to our targeted data users is the minimum "action" we conduct as part of a holistic monitoring design. It would be equivalent to delivering our story or book

to our agent. We may take other action with the information, or story, such as, modifying a BMP or developing a watershed plan, but reporting is the minimum. Monitoring results are always just results. This phase addresses you plan to transform numbers into information. What will you do?

We organized this phase into, data summaries and analysis, interpretation, conclusions and recommendations, communication and delivery of information and finally data management plans that support all the steps in Phase 3. Database functions to produce information are usually different than those used for data entry, validation and storage.

The Steps in Phase 3 include:

Step 12: **Data Summary and Analysis**
What is your planned starting point to summarize and analyze the raw data to answer monitoring questions for targeted decision makers?

Step13: **Interpretation, Conclusions and Recommendations**
What is your planned starting point to take the data summaries and analyses and interpret it, formulate conclusions and develop recommendations if that is what the targeted decision makers require?

Step 14: **Communication and Delivery**
What will you report or deliver, when and who will do it are some of the questions along with ideas on reporting?

Step 15: **Management to Generate Information (Data Management Plan Part 2)**
What support tools do you need to turn data into information that retains data integrity, processes as well as hardware and software

How to Use this Workbook

The overview section provides more introduction and basic background and information. It is highly recommended you read this before you start any Phase or Step. Each Phase and Steps are designed to develop and produce a Watershed Monitoring and Assessment Plan. Each Phase focuses on one critical aspect of an M & A Plan.

The format of each step is designed for you to understand 1) what you can accomplish, 2) why the products of this step are important, 3) what products you will produce, 4) basic steps (activities and worksheets) to produce the products, 5) worksheets and instructions, 6) background and content if you need more understanding to complete basic tasks, 7) case studies, 8) references and 9) resources. Four basic tasks are the same for each step. In the first two basic tasks we ask you to determine who should be involved in planning this step and to identify and evaluate what decisions have already been made regarding the specific step.

The last two basic steps involve putting the products of that step into a master Monitoring and Assessment Plan and to identify any needs you still have regarding that step in order to fully implement your M & A plan and place those in an Action Plan. Thus, both the Monitoring and Assessment Plan and Action Plan are accumulative, adding to an existing document and list after

each step. At the end, you have a documented M & A plan and one of the last tasks has you prioritize your Action Plan (from all steps) on a timeline.

The worksheets are designed to be modified to meet your needs and completed electronically. However, they can be completed by hand as well. This is why they are simply formatted in word. The workbook comes with a compact disc for this purpose.

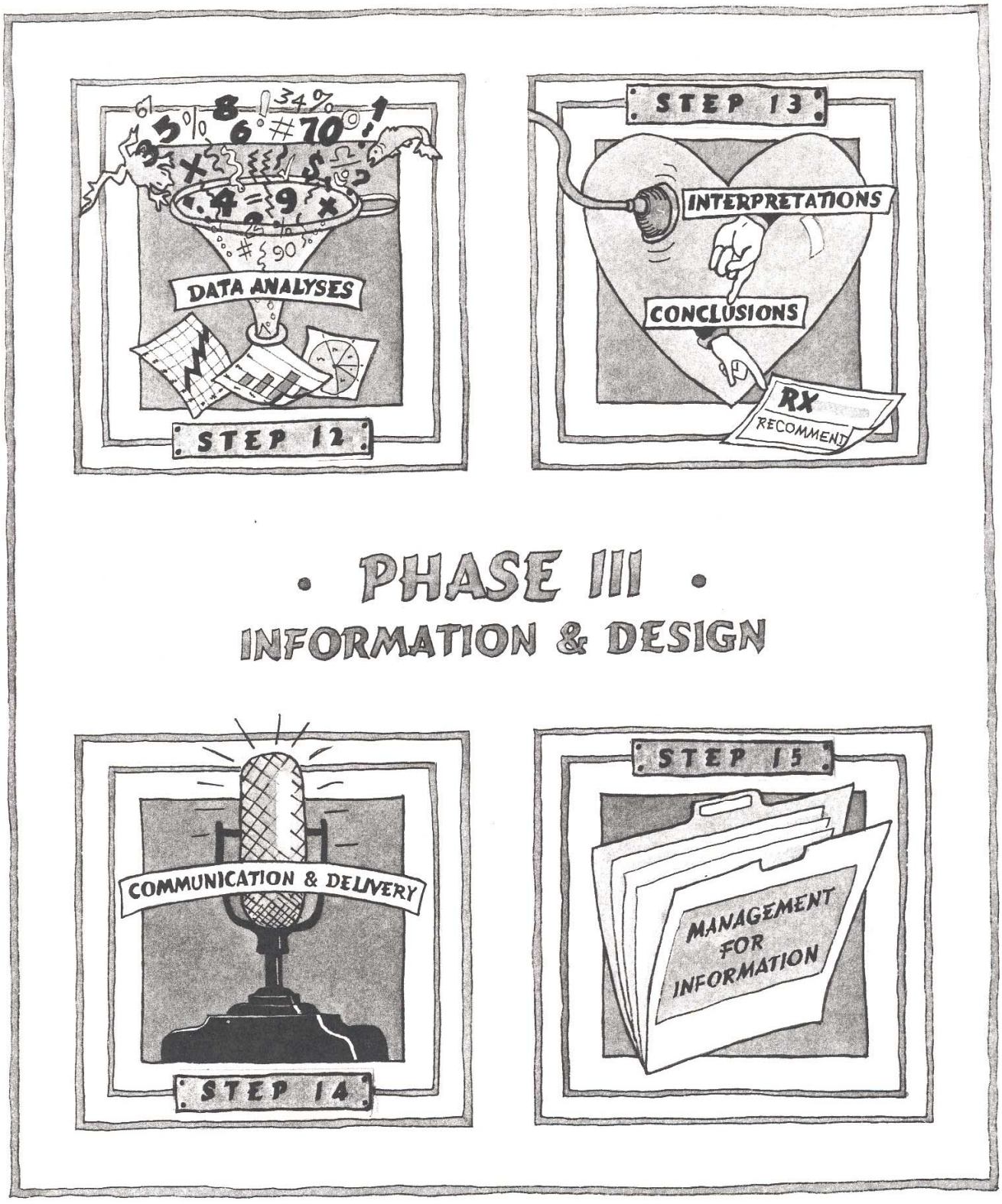
Remember that planning is dynamic, never complete, an iterative and not linear process. The amount of time and rigor you spend on each step is based upon your specific needs. If you skip a step, know why you skipped it. If you don't need to document or communicate or integrate components then don't, but know why. We are suggesting that every monitoring and assessment activity should address or consider all Phases and Steps at the appropriate level.

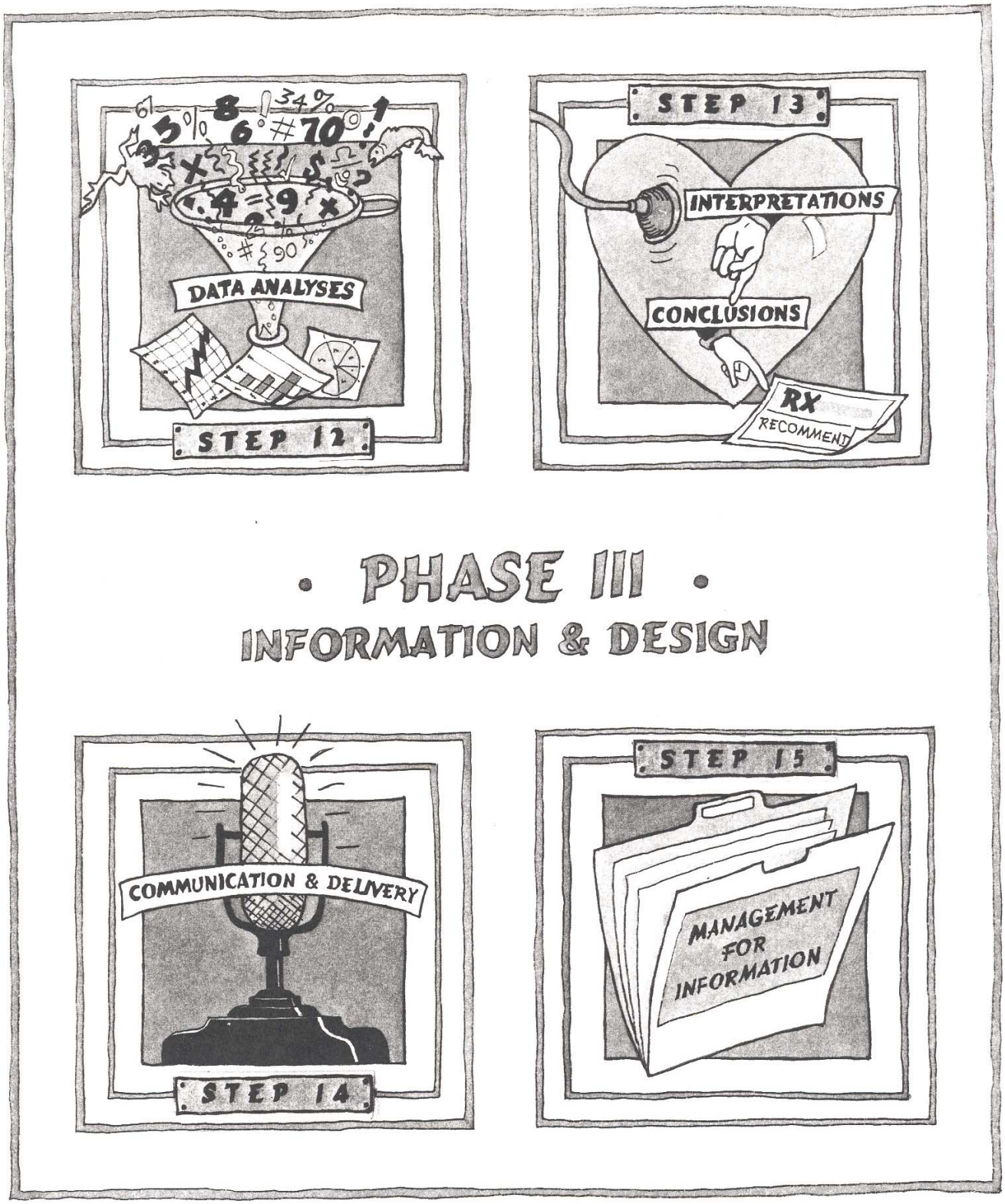
Start where you are with what is known and expand your horizons. If the step seems too much for your needs, complete what you need and leave the rest. If it seems overwhelming, start with something and do it well. There is no right or wrong, no time limit, just start somewhere. Planning, implementing monitoring and assessment activities is not a black and white science. Embrace that you often will be "breaking trail", there is not clean answers for everything even though there are experts out there, but use what you can that they provide.

In the end if you can justify and articulate your monitor and assessment activities to someone, and can evaluate your results against your goals, then you have succeeded.

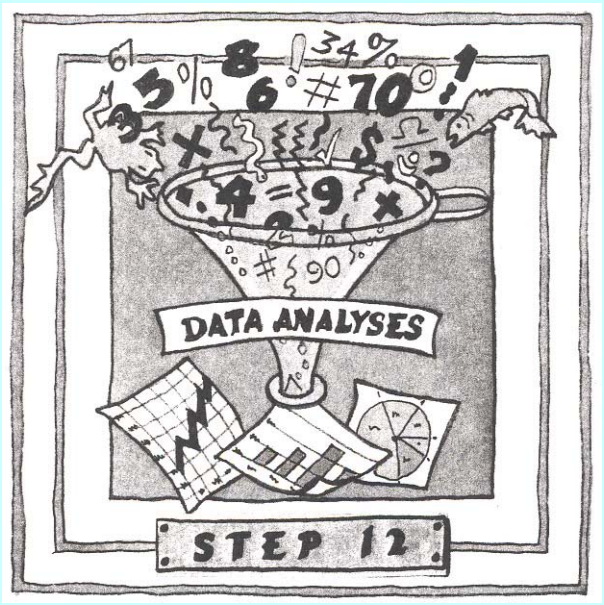
Watershed Monitoring and Assessment Design Workbook Phase and Step Illustration

Steps in:




DATA ANALYSES
STEP 12
STEP 13
INTERPRETATIONS
CONCLUSIONS
RX
RECOMMEND
PHASE III
INFORMATION & DESIGN
COMMUNICATION & DELIVERY
STEP 14
STEP 15
MANAGEMENT FOR INFORMATION

Step 12: Data Summary and Analysis



"I believe the challenge we all face is making a home, restoring, building, investing in, and reclaiming a community, a destiny, a way of life. I believe we all need to choose some ground and stick to it, no more frontiers and greener pastures, this is what we are fortunate to have."

Winona LaDuke

About This Step – *This step is designed to accomplish 3 things:*

This step is where you describe how you will explore and summarize your data:

1. Reduce the volume of the data set to a manageable size by summarizing it
2. See patterns and trends in your data by using some fairly simple data analysis tools
3. Develop a set of findings (objective observations) about your data.

Why Do This Step

The place to start is getting to know your data set. If you have a large data set or data from several years, comprehending all of it will be challenging and your story may be buried amidst the numbers. Simple statistics and biometrics can help by reducing the volume of numbers you have down to something more manageable:

Statistics are simply descriptions of a set of data. The ones we cover in this workbook describe values typical of the data set (e.g. average) and the variability of the data (e.g. minimum and maximum).

Biometrics are summary numbers that represent different aspects of the community of critters you collected (e.g. # of critters or # of different kinds of critters).

Using a set of fairly simple calculations, you can reveal a surprising amount of information about patterns and trends and the quality of your data. This enables you to make ***findings*** (objective observations) that form the foundation for understanding what's going on in your It doesn't take too many monitoring seasons for you to amass a very large number of data points. This step is all about getting it into a form you can deal with. Before long, you have far too many numbers to wade through to find the information there. Analyzing your data in different ways helps you to see the different facets in a systematic way.

A table, if it's not too large, is a good place to start. Putting the statistical and biometric summaries in a more visual form, primarily graphs, may help you see patterns and trends more clearly over time and space.

Variability and Your Results

Remember that a major part of watershed assessment is distinguishing between three types of variability:

- ✓ Natural variability produced by changes and cycles in natural stressors.
- ✓ Human-induced variability produced by human stressors and activities
- ✓ Sampling and analysis variability produced by errors in your sampling and analysis.

This step is where you try to do that, using the relatively simple statistics and metrics described later in this step, and using benchmarks that help you understand what is the "natural" range of results one might expect in your waters.

Changes due to errors in sampling or analysis give you false signals. You might see a trend that isn't there, conclude that conditions are worse, or better, than they really are, etc. Naturally occurring changes and those caused by human activities give you a true picture. They reflect what's really happening in the watershed. Assuming you can distinguish between the two, your data user(s) can use this information to make protection and restoration decisions.

This step is challenging for several reasons:

- ✓ You may not have collected any data yet, and here you are trying to figure out how you're going to make sense of it.
- ✓ How you interpret the data is a process that builds on your actual results.
- ✓ It's where objective facts get turned into opinions about what's going on in your watershed.

Data can be summarized in various ways. In this workbook, we focus on simple statistics, metrics, and graphs as the basic tools to help you come to grips with the data. Which statistics or metrics you use depends on the type of data you are working with. In this workbook, we focus on several different kinds:

- ✓ Water Column
- ✓ Aquatic Life
- ✓ Lake Trophic Status
- ✓ Physical Habitat
- ✓ Riparian Vegetation
- ✓ Quality Control

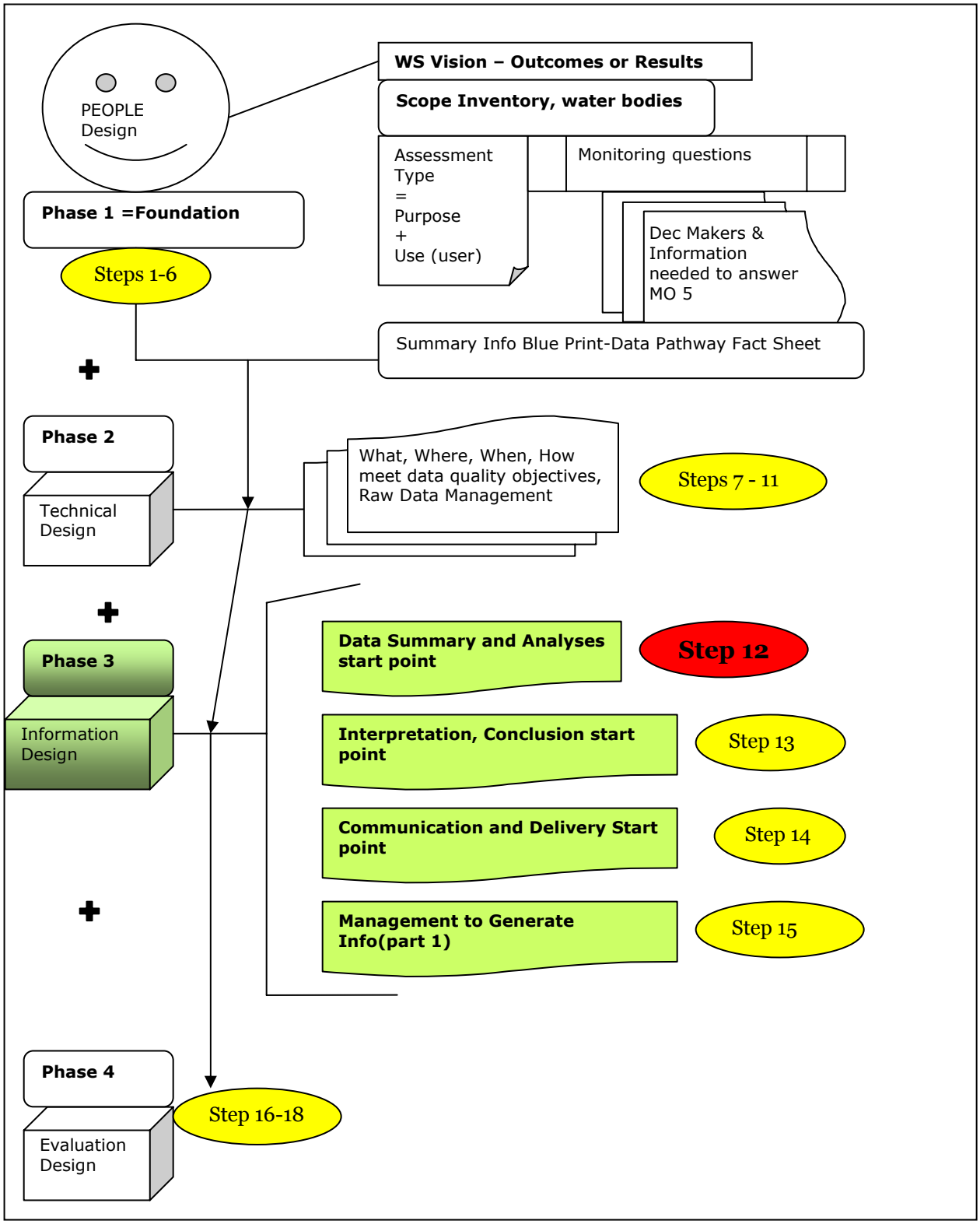
Where are we in the Big Picture Illustration?

Phase 1	Step 1: Share Watershed Vision and Desired Outcomes (Results) Step 2: Scope Inventory (Physical, People and Information) Step 3: Identify Monitoring Reason(s) and Data Use(s) (Assessment Type) Step 4: Develop Monitoring Questions (Refinement of Monitoring Reason) Step 5: Target Decision Makers and Info Needs (Refinement of Data Use) Step 6: Summarize with Information Blue Print-Data Pathway Fact Sheet)
Phase 2	Step 7: What Will You Monitor? Step 8: When Will You Monitor? Step 9: Where Will You Monitor? Step 10: How Will You Monitor to Meet Data Quality Objectives? Step 11: Management of Raw Data (Data Management Plan Part 1)
Phase 3	**Step 12: Data Summary and Analysis** Step 13: Interpretation, Conclusions and Recommendations Step 14: Communicating and Delivery Step 15: Management to Generate Info (Data Management Plan Part 2)
Phase 4	Step 16: Who Will Do What? Task Identification Step 17: Evaluation of Effectiveness (of Plan and Implementation) Step 18: Documentation and Communication (of M & A Plan)

Products (see Figure Phase 3 Product List):

- ✓ An identified method for comparing your quality control data to your data quality objectives.
- ✓ Benchmarks established for each parameter
- ✓ A methodology for comparing your data to each of the benchmarks
- ✓ The statistical measures you will use to summarize the central tendency and variability of the data.
- ✓ How you will develop a set of findings based on the statistical summaries: which questions will you ask of your data?

Phase 3 Product Illustration:



What Should Be Done Before This Step

The results from Phase 1 or the people orientation provides the foundation for Phase 2 Steps. Thus, ideally you need to have identified a watershed vision and desired outcomes with associated assumptions and external factors. Defined combination of monitoring reasons and uses, we call Assessment types. For each assessment type a list of monitoring questions the data is to answer and how that question will be answered. For each monitoring question, a list of targeted decision makers, their decision, how they make that decision and what information they need to make the decision. A format to document and summarize the results, we have suggested the information blueprint.

The results from Phase 2 Steps, provide the foundation for Phase 3 Steps. Steps 7-9 identify indicators, characterize frequency, and identify sites that will answer monitoring questions. Step 10 identifies and documents methods, data quality objectives and quality control procedures necessary to make the desired decisions. Step 11 defines how raw data will be managed to be ready for Phase 3, turning that raw data into information to be delivered.

Basic Tasks

Basic Tasks are numbered to correlate with the overall 1-18 Steps provided in these guidance modules followed by the basic task sequence step to complete. For example Step 4, basic task 2 would be numbered as Basic Task Step 4.2, Step 3.3 correlates to Step 3, Basic Task 3.

 12.1 Identify who will make the decisions about this step and who should be involved in the planning process (they may be different).

 12.2 Self Assessment: If you've been monitoring before you've undertaken this process, has your data analysis worked well?

 12.3 Choose benchmarks and the methodology you will use to compare your results to them.

Note that (when this may need to be done after task 12.4, since some of the comparison methodologies use the summary statistics.

 12.4 Decide how you will summarize the data.

 12.5 Decide how you will analyze your quality control sample data.

 12.6 Summarizing Your Data Using Tables and Graphs

 12.7 Data Analysis – How You Will Develop Findings

 12.8 Update *Data Management Plan Part 1*. See provided outline in Step 11, edit or develop your own for these items.

 12.9 Update *Inventory Master List* and *Plan.*

 12.10 Update *Information Blueprint – Data Pathway Fact Sheet* for each monitoring question.

 12.11 Place Products in your *Watershed Monitoring and Assessment Plan*.

 12.12 Place your identified gaps and needs regarding this step in the *Action Plan* (what you need to plan to complete this step and or overall monitoring and assessment plan).

Worksheets

Work sheets are listed below. Not all Basic Tasks have an associated work sheet. To simplify completion of products for each step, the worksheets or broken into small subsets of tasks. This requires moving the results of one task into the next task and will seem redundant, especially if completing worksheets by hand. Worksheets are provided in word here for ease of reproducibility. These are a starting point, we encourage you to customize these and reproduced them in an electronic format, in Excel for example, where it is easy to move information from one area to another by cutting and pasting.

Work Sheets are numbered to correlate with Basic Steps and the overall Steps in these guidance modules. Each consecutive work sheet is lettered a, b, c and so forth , preceded by the Basic Task sequence step, preceded by the Step number. For example, Worksheet Step 4.2.a and Step 4.2.b, correlates to Step 4, Basic Task 2, Worksheet a and Worksheet b. In theory worksheet a needs to be completed before worksheet b.

Worksheet 12.2.a	**Self Assessment Step 12 Worksheet and Products to be completed Prior to this Step, Part 1 and Part 2**
Worksheet 12.3.a	**Decide the benchmarks to which you will compare your results and how**
Worksheet 12.4.a	**Decide how you will summarize the data**
Worksheet 12.5.a	**Decide how you will analyze your quality control sample data.**
Worksheet 12.6a	**Data Summary using Tables and Graphs**
Worksheet 12.7a	**Data Analysis – How You Will Develop Findings**
Worksheet 12.11.a	**Place Products in your *Watershed Monitoring and Assessment Plan.***
Worksheet 12.12.a	**Place your identified gaps and needs regarding this step in the *Action Plan* (what you need to plan to complete this step and or overall monitoring and assessment plan).**

How to do Worksheets

For Sheet 12.2.a Self Assessment Step 12 Worksheet and Products to be completed Prior to this Step, Part 1

Part 1. Complete the self assessment section of the worksheet to evaluate what you have or what decisions have already been made. This will help you focus on what you need from this step and incorporate valuable existing information or products into this plan.

Part 2. Next, to prepare to complete this step the following, you need to have the following items addressed:

- ✓ Desired set of outcomes or results that the monitoring and assessment activities will be designed to help achieve
- ✓ Identified monitoring and assessment activities, specific combinations of a monitoring reason plus an associated data use; we call this an Assessment Type. You may have multiple Assessment Types.
- ✓ For each Assessment Type, the list of specific monitoring questions the monitoring and assessment will be designed to answer.
- ✓ For each monitoring question, the targeted decision makers, the type of decisions they will make and the information they need to make them (as specific as possible).
- ✓ A minimal scoping inventory that identifies the watershed boundary and water bodies you are focusing on (rivers, lakes or wetlands), physical attributes of water bodies (including status, uses, etc.), relevant cultural or historical aspects, existing data sets or monitoring efforts and others in the watershed who either you want to influence or could help you implement.
- ✓ Technical sample plan including what monitor (indicators, benchmarks, criteria, etc.), where and when monitor, how will meet data quality objectives (methods, how good does the data need to be for decision makers, quality assurance and control measures), and how will manage and verify raw data/information.

This is the ideal list, if you do not have any of these, they become a gap or need that should be addressed before any data is collected or analyzed, even if the answers aren't perfect or you don't have a large degree of confidence surrounding them, they should be attempted as the starting point. This is what you are evaluating in this step-your monitoring and assessment plan.

Worksheet 12.2.a Self Assessment Step 12 Worksheet and Products to be completed Prior to this Step, Part 1

Part 1 Self Assessment of Known Evaluation Products and Processes

1. **Determine if you "have" or "don't have" the item, mark the appropriate box. If you don't have it and determine you don't need it, explain why in the comments document. You may not need to know but perhaps your target decision makers, board or membership might want to know.**

2. **If you have the item "documented", mark that box. If so, list in the comments where, hard copy, chapter in a document, electronic file name and location, etc. The assumption is you value the ultimate goal to document and communicate your M & A plan, activities and results.**

3. **If you have the item, assess the use of it, use the scale below or provide your own answer and comments.**

   Rating Scale for USE:

   0=doesn't exist so use is nil
   1=don't know why would need or understand item
   2=exists, don't know where it is, if it is used, etc. so use is essentially nil
   3=exists and use some of time
   4=exists and use all the time
   5=wish it existed, would use it lots

4. **If you have the item, assess the effectiveness of it, just because something exists or is used does not mean it is effective in its use, use the effectiveness scale below or provide your own answer and comments.**

   Rating Scale for EFFECTIVENESS, assumes material exists:

   0=not effective or functional at all
   1=incomplete (all elements are not there) and some existing parts need revising
   2=incomplete but what is there is okay
   3=complete (all elements are there), some parts okay but need revising
   4=complete and effective

Item	Have	Don't Have	DOC	Assessment of Use (Scale 0-5)	Assessment of value / effectiveness (Scale 0-4)	Comments/Notes
41. Starting point for Data analyses for each indicator used in monitoring / assessment program (first cut at what will do)						**Phase 3 Step 12**
Other ?						

*DOC=Documentation, *M & A= Monitoring and Assessment

5. **To make this assessment useful, determine what your gaps and needs are regarding this step in order to focus your effort in completing this step.**

Worksheet 12.2.a Self Assessment Step 12 Worksheet and Products to be completed Prior to this Step, Part 2

Part 2 Products to be completed before this step, in order to complete this step

Item	Response
Desired set of outcomes or results that the monitoring and assessment activities will be designed to help achieve:	
Assessment Types, specific combination of one monitoring reason and data use(r):	
For each Assessment Type, the list of specific monitoring questions:	
For each monitoring question, the targeted decision makers, the type of decisions they will make and the information they need to make them (as specific as possible):	
Watershed(s) and Water bodies of focus:	
Physical attributes of Water bodies (status, use, etc.)	
Existing Data or monitoring efforts:	
Indicators, benchmarks and criteria list:	
Characterization of monitoring frequency:	
List of monitoring locations/rationale:	
Methods list, list of data quality objectives (methods, how good does the data need to be for decision makers), quality assurance and control measures)	
Plan for raw data management and support mechanisms:	

For Sheet 12.3.a Decide the benchmarks to which you will compare your results and how.

Benchmarks define the conditions we're trying to achieve for our waters. For example, what should transparency be in a healthy lake? What mix of aquatic invertebrates should we find on the river bottom? What bacteria levels are safe for recreation? There are three basic types of benchmarks we'll cover in this module:

- ✓ **The criteria in the water quality standards**
- ✓ **Ecoregion or Regional Reference Site Guidelines that come from a long-term data set**.
- ✓ **Watershed Reference Sites or a baseline, that are specific to your watershed, and which you monitor with the rest of the sites.**

You will likely be summarizing your data as you start this process, but for now we want to start with the benchmarks – which will drive how to do the summaries you will learn about in worksheet 12.3.a. In the worksheet, please fill out the following columns:

Parameters

List all the parameters you will measure.

Benchmarks and Comparison Methodology You Will Use

A benchmark is what you compare your results with to assess the health of the waters you are monitoring. There are 3 main options:

1. **Water Quality Standards**: Use the criteria in the water quality standards and your state's 305b assessment methodology, which explains the mechanics of the comparison. See the "Rocky Mountain States Implementation of the Clean Water Act" module.
2. **Regional/Ecoregional Guidelines:** Use benchmarks (such as Ecoregion Guidelines) that come from a long-term data set, but likely with no established methodology for comparison.
3. **Reference Site(s) or baseline:** Do comparisons within your data set, more specifically, establish a baseline and/or reference site for each type of water body you are assessing.
   - ♦ A **baseline** is the range of results that are typical or expected for your waters, based on a long-term data set that you, or others collect.
   - ♦ A **reference site** is an actual place where samples are collected, that represents conditions largely unaffected by humans.

On the worksheet, in column 2, note the classification of the water body (e.g. Class 2, swimming, etc,) and the criteria that apply to each of your parameters.

Who Will Analyze the Data?

This is not a list of your samplers: it refers to the organizational/agency level that will perform the analyses.

Do the Data Users Require this Data Analysis Methodology?

Back in step 5, you identified your data users and their information needs. Here you note whether the method(s) you are using to compare your results to the benchmarks are the ones they require, or at least will accept. Note that this may need to be done after worksheet 12.4.a, since some of the comparison methodologies use the summary statistics.

Example 1 of Worksheet 12.3.a Compare Your Data with Benchmarks

Water Body Assessed: Trout River

Type of Assessment: Condition and Trend

Parameter	Analytical Benchmark and Methodology	Who Will Analyze the Data?	Do the Data Users Require this Protocol?
Fecal coliform bacteria	**Benchmark Used:** Water Quality Standards (WQS): ≤ Geometric Mean of 200 (Class 2) **Methodology** Water Quality Standards **Step 1:** % exceedance of 200 orgs/100 ml. If ≥ 10% exceed, then move to next step **Step 2:** # of months w/geomean>200 orgs/100 ml OR % exceedence of 200 orgs/100 ml	Friends of Trout River	Yes, DEP specifies a 2-step protocol for 305b Yes, SWCD will accept this protocol as well
Benthic macroinvertebrates	**Benchmark Used**: Reference Site IBI: An IBI (Index of Biotic Integrity) – we will talk with DEP about new specific benchmarks in our basin. **Methodology** Metrics will be calculated. Results will be compared with reference sites and a % similarity calculated.	Consultant that we hire will help us.	No DEP says biological criteria are pending, but will not be in place for a year We will keep all samples to re-run metrics as needed.

Worksheet 12.3.a Benchmarks and Comparison Methodology

Parameter	Analytical Benchmark and Methodology You Will Use	Who Will Analyze the Data?	Do the Data Users Require this Protocol?
	Benchmarks **Methodology**		
	Benchmarks **Methodology**		
	Benchmarks **Methodology**		
	Benchmarks **Methodology**		

For Sheet 12.4.a Data Summary

Statistics are simply descriptions of a set of data. Using some simple statistics, you can reduce the volume of data to relatively few numbers that summarize the data set. These statistics are designed to summarize your data in two main ways:

- By giving you values which are ***representative or typical*** of the data set
- By giving you the ***range or spread*** of your data set which tells you something about its variability.

Your study design should describe which statistical summaries you will use to reduce your data set to a manageable size. See the Background and Content section for more information on of each type of statistical summary, and suggestions for when to use them.

Statistics Commonly Used for Water Column Data

- ✓ **Average (Arithmetic Mean)**
- ✓ **Range** (Maximum and Minimum)
- ✓ **Quartiles and the Inter-quartile Range**
  - the **50th Percentile** (a.k.a.) **median**
  - the **25th percentile** (aka P-25)
  - the **75th percentile** (aka P-75)
  - The **inter-quartile range**
- ✓ **Geometric Mean**

Parameter or Type of Data

In this section, you list the type of data or parameters you will be measuring:

Type of Data/Parameter

- Water Column: e.g. DO, Temp, pH . . .
- Aquatic Life: (e.g. fish, benthic macroinvertebrates, plants)
- Lake Trophic Status (e.g. the
- Physical Habitat
- Riparian Vegetation
- Quality Control
- . . . and/or the parameters to be measured.

Statistical Summaries

In this section, you list the statistics you will calculate, for each type of data or parameter you will be measuring.

Summarizing Your Aquatic Life Data Using Biometrics

The numbers of plants or critters in various taxonomic groups are frequently summarized using metrics that represent different aspects of the part of the community. Some of the statistical summaries used for core indicators can also be used on the metrics values, especially when you have more than 5 years of data. Individual metrics that respond in a predictable way to watershed stressors are frequently combined into a ***multi-metric index***.

Which metrics you can calculate depends on whether you used quantitative or qualitative collection methods and to what taxonomic level you were able to identify the critters. Individual metrics are frequently combined into a multi-metric index. These are calculated by applying some sort of scoring system to the individual metrics results and adding the scores to come up with a total score or index. Examples include the EPA's Total Metric Score in the Rapid Bioassessment Protocols, Ohio's Invertebrate Community Index or Karr's Benthic Index of Biotic Integrity.

Total scores or indexes for each site may then be compared with scores or indexes for regional or upstream reference sites. Reference sites are minimally impaired sites which are similar in most characteristics (especially habitat) to the sample site. Some approaches produce a percent comparison to the reference site by dividing the score or index for the monitored site by the score or index for the reference site.

Metrics Commonly Used for Fish Data

Richness Measures The number of distinct taxa in the sample

Composition Measures The percent of the sample in selected taxa.

Tolerance/intolerance measures Represent the relative sensitivity to perturbations

Feeding Measures Balance of feeding strategies in the sample (e.g. predators, grazers, shredders, collectors)

Habit Measures Describe the behavior and adaptations

Life Cycle Measures Describe the length of life cycles

Metrics Commonly Used for Benthic Macroinvertebrate Data

Richness Measures: The number of distinct taxa or groups in the sample

Number and Identity of Species: Diversity and identity of indicator species

Number of Intolerant Species: Number of species that are intolerant of chemical and physical perturbations

Feeding Measures: Balance of feeding strategies in the sample (e.g. insectivores, omnivores, carnivores)

Abundance Measures: The number of individuals in the sample

Reproductive Measures: Measure of the suitability of the habitat for reproduction

Disease Measures: The percent of the sample that shows evidence of disease

The Carlson Trophic State Index (TSI) The index is a quantitative scale from 0-100. High values indicate a more trophic condition. The scale is divided into four categories: Oligotrophic (0-40), Mesotrphic (40-50), Eutrophic (50-70) and Hypereutrophic (>70).

Statistics For Lake Mixing and Trophic Status Data

Mixing status is the frequency with which the water column mixes from top to bottom.

The Carlson Trophic State Index (TSI) can be calculated using the following 3 values:

- *secchi disk* mean summer transparency and the mean epilimnetic (upper layer)
- *Chlorophyll a* mean summer concentrations
- *Total Phosphorus* mean summer concentrations.

These three values can be looked at individually and then averaged into a single TSI value.

Metrics Commonly Used for Periphyton Data

Abundance Measures: Represents the amount of production

Richness Measures The number of distinct algal species in the sample

Composition Measures The percent of the sample in selected taxa or groups.

Pollution Tolerance Measures Represent the relative sensitivity to perturbations

Summarizing Your Physical Habitat Data

Geomorphology: This includes various measurements of the stream bottom, the depth to which the stream has carved its channel, channel width/depth ratio, sinuosity (meandering pattern), number of channels, slope. These data can be summarized in several ways:

- **Stream Classification**: There are various systems that use the basic data to divide streams into different types.
- **Channel Evolution Models**: Describe the sequence of changes a stream undergoes after certain kinds of disturbances.
- **Proper Functioning Condition**: This is a methodology for assessing the physical functioning of a streamside wetland area. The result is an assessment that places an area into one of 3 categories: proper functioning, functional-at-risk, or nonfunctional.
- **Stream Stability**: This summarizes data to assess whether a given reach is stable and, if not, whether its just a local condition or stream system-wide.

Flow: Flow (aka "discharge") data describe the volume of water passing by a particular location over some time interval. At the simplest level, flow data are typically summarized as cubic feet per second. Other types of flow summaries include:

- **Flow Duration**: This is the amount of time certain flow levels exist in the stream. This is usually expressed as the percentage of time a given stream flow of interest (e.g. drought or flood flows) is equaled or exceeded over a given period. These are summarized using "flow duration curves.
- **Flow Frequency**: This is the probability (or a percent chance) that a given flow will be exceeded in a given year. These frequencies are determined by applying statistical

methods to a long-term set of flow data. The flows of interest are usually one or all of the following:

- **Flood frequency**: the probability that given flood flows will occur in a given year.
- **Low flow frequency**: the probability that given low flows will occur in a given year.
- **Channel-forming flow**: This is actually a variety of theoretical flows that maintain the geometry of the channel. Common measures are the bank full discharge, effective discharge, mean annual flow, etc.

Substrate Quality: The substrate is the bottom of a water body. Quality refers to its usefulness for various biological functions, such as attachment, shelter from the current, shelter from predators, spawning, rearing, etc. It is usually based on an inventory (aka "pebble count") of the number of particles in various size classes, such as bedrock, boulders, cobble, gravel, and, silt, and organic material. The most common summary technique is a size distribution. This plots the different particle sizes according to the frequency with which they occur at a given location. These distributions are then related to the requirements of different organisms.

Riparian Vegetation: The data gathered are typically focused on changes and functions of vegetation close to the water.

Worksheet 12.4.a Data Summary: List the statistical tools (if any) will you use to summarize your data.

Indicator or Type of Data	Statistical Summary or Metrics

For Sheet 12.5.a Evaluation of Quality Control Results:

Type of Quality Control Sample

Fill in the type of quality control samples you will use.

Statistical Tools

Fill in the statistical tools you will use to determine whether you've met your data quality goals. Following are brief description of each tool.

When you are comparing more than two values (replicates) use one of the following statistical methods.

Standard Deviation (Std Dev): It is used to compare how closely three or more values (replicates) are clustered around the average value and is expressed as ± from the average value. It indicates the range of variation in the measurements you've made. When used with replicate samples, Std Dev measures precision. The lower the Std Dev, the more precise the results are. Many calculators can perform the Std Dev calculation. Microsoft Excel also has this function.

When you are comparing only two values (duplicates) use one of the following statistical methods.

Coefficient of Variation (CV): It is the Std Dev as a percentage of the average. When used with duplicate samples, CV measures precision. The lower the percentage, the more precise the results are. This can also be done with some calculators and Microsoft Excel.

CV = Std Dev / mean X 100

Relative Percent Difference (RPD): It is used to compare how close the result from a water sample is to the true result. It is expressed as either a positive difference when the sample result is higher than the true value or a negative difference when the sample result is lower than the true value. When used with duplicate samples, the RPD measures precision. The lower the RPD, the more precise the results. It can also measure accuracy. That is when one of your results is the true value, such as the quality control lab results for a split sample, or the actual concentration of a known or unknown sample.

RPD = (larger value – smaller value) / ((larger value – smaller value) /2) X 100

Percent Recovery: is the percentage of the substance added to a sample that is detected. It is the difference between the concentration detected in the spiked sample and that detected in the un-spike sample, divided by the concentration of the substance added to the spike sample times 100. Percent Recovery is a measure of accuracy. The higher the percent recovery, the greater is the accuracy.

$$\%\ \textbf{Recovery} = \frac{\text{(Concentration of spiked sample – Concentration of un-spiked sample) x 100}}{\text{Concentration of spike added}}$$

Worksheet 12.5.a Evaluation of Quality Control Results:

List the statistical tools (if any) will you use to compare your quality control results with your data quality objective for each type of quality control sample.

Type of Quality Control Sample	Statistical Tool

For Sheet 12.6.a Summarizing Your Data Using Tables and Graphs

This worksheet covers the tables and graphs you will create to help you interpret your data. These may or may not ever be presented to any audience other than you.

Indicator or Type of Data

Fill in the parameter or type of data you are working with.

Types of Tables

A table presents the numbers in an organized way, typically in columns and rows There are two types of tables we recommend. One displays all of your data. The other shows the statistical summaries of this large data set. Tables that display all of your data should be used for reference, to make data available that are obscured when displayed in graphs or summaries. These might be quite large and complex.

A good table has . . .

- ♦ readable, logical data placement
- ♦ clear column and row headings
- ♦ a title at the top
- ♦ reporting units

Describe the types of tables you will create. Please list:

- ✓ title of the table
- ✓ what will be the row headings
- ✓ what will be the column headings.

Types of Graphs

We suggest keeping the graph types simple. For example:

- Column graphs plotting results for a single parameter over time at one or more sites
- Box and Whisker plots, which show the results for sites (arranged upstream to downstream, for each main stem or tributary, over a period of time.
- Combination graphs which plot two parameters (2 'y' axes) over time.

A good graph. . .

- ♦ Is visually interesting
- ♦ Is appropriate for the type of data
- ♦ Has clear axis labels
- ♦ Has a title at the top
- ♦ Has reporting units
- ♦ Is not too cluttered

Describe the types of graphs you will create. Please list:

- ✓ title of the graph
- ✓ what will be on the 'x' axis
- ✓ what will be on the right axis.

Worksheet 12.6.a: Summarizing Your Data Using Tables and Graphs

List the types of tables and graphs you will use to summarize your data.

Parameter or Type of Data	Types of Tables	Types of Graphs

For Sheet 12.7.a Data Analysis – How You Will Develop Findings

Findings are observations about your data. They are the statements that summarize the important points but do not explain them. We tend to look at data and then begin to try to explain it before thoroughly observing and summarizing the trends, patterns or lack of patterns. Findings should support your conclusions.

For example, let's look back at the sample "box and whisker" plot. Let's assume that site 1 is the reference site and we are using a criterion, which says, that sites with inter-quartile ranges that don't overlap with the reference site are significantly different. Your findings could be:

- the site most like the reference site is site 7,
- the sites least like the reference site are sites 5 and 10 (though they are quite similar to each other), and

In order to help you develop findings, look for patterns within your data set as well as comparing your results to reference conditions, you might answer any of the questions listed below.

Quality Control Questions to ask of your data set

- Did you collect the required number of samples from the minimum number of sites (completeness)?
- Did you collect samples frequently enough, at the right time of year, at the right time of day to be representative of the conditions you are assessing?
- How did your quality assurance results (from split, duplicate, spiked, replicate, known, unknown, and blank samples) compare with expected results? Did they meet your data quality objectives?

General questions to ask of your data set

- Which sites had the highest or lowest readings?
- Which dates had the highest or lowest readings?
- Which tidal stage had the highest or lowest readings?
- Are there numbers that seem to be much higher or much lower than typical results ("outliers")? Are you confident that these numbers are reliable? Verify that the numbers were transcribed or entered correctly.
- Do your results show a consistent pattern of change upstream to downstream or close to and further from the impact source? Do levels increase or decrease in a consistent manner?
- If you are monitoring the impact of a pollution source, for example, are your results different above and below the impact or at different tidal stages?
- Do changes in one indicator coincide with changes in another? As illustrated earlier, there is usually an inverse relationship between water temperature and dissolved oxygen, since warm water can hold less oxygen than cold water. There's a similar relationship between an increase in water column algae and a decrease in water clarity.
- How do your results compare among tributaries?

Questions to ask of your data when comparing them to benchmarks / reference conditions:

- **Comparisons with maximum and minimum**: Did the results exceed the maximum and minimum acceptable levels set by the tribe. Where? When?
- **Comparisons with ranges**: Were the results inside or outside of your acceptable range? Where? When?
- **Comparison with allowable number of times that results did not meet your reference conditions**. Your reference conditions or your assessment procedure might specify a maximum number of times, or percent of the time, when results do not meet standards. How many times (or what percent of the time) were reference conditions not met? Where? When?
- **Sampling dates**: Are there sampling dates when most or all results did not meet your benchmarks?
- **Special weather or hydrologic conditions**: Were there any conditions (dry or wet periods; large or long precipitation events; tidal stage; wind conditions; day of the week; time etc.) when most or all results did not meet your benchmarks?

Worksheet 12.7a Data Analysis – How You Will Develop Findings

Assessment Type:	
Monitoring Question	**Questions You Will Ask of Your Data Set**

For Sheet 12.11.a Place Products in your *Watershed Monitoring and Assessment Plan*.

- An identified method for comparing your quality control data to your data quality objectives.
- Benchmarks established for each parameter
  - A methodology for comparing your data to each of the benchmarks
  - The statistical measures you will use to summarize the central tendency and variability of the data.
  - How you will develop a set of findings based on the statistical summaries: which questions will you ask of your data?
- Basic starting points for data summary & analysis

Worksheet 12.11.a Add products of Step to *Monitoring and Assessment Plan.*

If you completed any Steps this Worksheet is cumulative, use that document. If you have not you complete that aspect that is highlighted for your plan documentation. **Italics mean a sub plan that might be attached or live somewhere else, location of document and contact is what would go in the plan.*

I. People Design, Phase 1

A. Shared Watershed Vision and Desired Outcomes (Step 1)

1. Logic Model of Desired Outcomes/Results and activities/target audiences to employ to achieve outcomes

B. Keepers of the M & A Plan (Step 1)

C. Watershed Boundary (Step 2)

D. Water bodies of Interest (Step 2)

E. Scope Inventory Master List* (Step 2)

1. Physical Inventory * (Step 2)
2. People Inventory* (Step 2)
3. Information Inventory* (Step 2)
    1. Existing Monitoring Efforts (Step 2)
    2. Existing Data Sources (Step 2)
4. Inventory Action Plan* (Step 2)

F. Assessment Type(s) List – Monitoring Reason + Use (Step 3)

1. Monitoring Question(s) (Step 4)
2. Targeted Decision Maker(s) (Step 5)
    3. Information Needs (Step 5)

3. Information Blue Print – Data Pathway Fact Sheet Per Monitoring Question* (Step 6)

II. Technical Design, Phase 2

A. What (Indicators, Benchmarks, etc.) and why? (Step 7)

B. When and why? (Step 8)

C. Where and why? (Step 9)

D. W(how) will meet data quality objectives? (Step 10)

1. Data quality objectives (Step 5 and 10)

2. Quality Assurance and Control Measures (Quality Assurance and Control Plan)* (Step 10)

E. Data Management for Raw Data (Data Management Plan Part 1)* (Step 11)

III. Information Design, Phase 3

A. Data Summary and Analyses (Step 12)

1. Starting Point (Step 12)

2. Changes (Later)

B. Data Interpretation, Conclusions, Recommendations

1. Starting Point (Step 13)

2. Changes (Later)

C. Communication and Delivery

1. Starting Point (Step 14)

2. Changes (Later)

D. Management Plans to Generate Information (Data Management Plan Part 2)* (Step 15)

IV. Evaluation Design, Phase 4

A. Who Will Do What? (Step 16)

1. Task Identification Matrix (Step 16)

2. Communication Structure and Tools (Step 16)

B. Evaluation Plans (Step 17)

1. Evaluation Plans for M & A Components (Step 17)
2. Evaluation Plans for M & A Implementation (Step 17)
3. Evaluation of inter/intra M & A Activities (Step 17)

C. Documentation and Communication (Step 18)

1. M & A Plan (**this document**, updated Sub documents) (Step 18)
2. Communication and Peer Review Plan (Step 18)
3. Action Plan* (Step 17)

For Sheet 12.12.a **Place your identified gaps and needs regarding this step in the** *Action Plan* **(what you need to plan to complete this step and or overall monitoring and assessment plan).**

Worksheet 12.12.a **Final** *Action Plan* **Part 1, Summary:**

If you have completed each Step, or for those you have, you have a cumulated list of gaps and needs related to that Step. Use that same worksheet/document. If you did not complete each Step, look at what each Step is supposed to accomplish and record what your gaps and needs are related to that topic. The goals are to get the gaps and needs in one place to evaluate and prioritize.

Phase 1 Step 1: : (completed in Step 1)
Phase 1 Step 2: : (completed in Step 2)
Phase 1 Step 3: : (completed in Step 3)
Phase 1 Step 4: : (completed in Step 4)
Phase 1 Step 5: : (completed in Step 5)
Phase 1 Step 6: : (completed in Step 6)
Phase 2 Step 7: : (completed in Step 7)
Phase 2 Step 8: : (completed in Step 8)
Phase 2 Step 9: : (completed in Step 9)
Phase 2 Step 10: : (completed in Step 10)
Phase 2 Step 11: : (completed in Step 11)
Phase 3 Step 12: Data Summary and Analyses
Phase 4 Steps: Will add Action and Needs as complete each Step and at the end prioritize

Background and Content

Remember that a major part of watershed assessment is distinguishing three types of variability:

- ***Natural variability*** produced by natural stressors. changes and cycles
- ***Human-induced variability*** produced by human stressors and activities
- ***Sampling and analysis*** variability produced by errors in your sampling and analysis.

You are going to collect data that might be explained by any of these three. Naturally-occurring changes and those caused by human activities give you a true picture—they reflect what's really happening in the watershed. Assuming you can distinguish between the two, you can use this information to make protection and restoration decisions. Changes due to errors in sampling or analysis give you false signals. You might see a trend that isn't there, conclude that conditions are worse (or better) than they really are, etc. So, it's very important to select indicators that can be measured using methods that minimize this type of change (see the "How" chapter).

Assuming you minimize measurement errors, you're left with the challenge of distinguishing between the natural and human-caused changes you measure.

Getting Started

Before you begin to try to understand your data, it's helpful to assemble some information which you gathered back in step 1:

- a map of your watershed with the sites marked on it and the classification of the segments you sampled.
- a map or list of open or closed fishing or swimming areas.
- a map of areas where community members most often use water and are exposed to pollution or toxics during traditional or contemporary practices.
- correct units of measurement clearly reported on your data tables and graphs.
- general observations, such as habitat, wildlife, tide, storm and wind-related surface water conditions, and weather information for each sampling date and site.
- your cultural ecosystem story or source of traditional ecological knowledge.
- the appropriate water quality standards (tribal and state or federal) or reference conditions for each indicator.
- historical or current information gathered from other water quality data sources, such as the state or other monitors, in a format similar to your data.
- anecdotal information on beaver pond construction (or "deconstruction"), highway projects, dam or tidal gate repair, intensity of various recreational uses, vacation home rentals, etc.

More About 305b Assessment Methodology

If your user is a state water quality agency, then you need to get a copy of the water quality standards and the latest 305b (or 303d) guidance to answer this question.

Also note the methodology you will use to make the comparison. The methodology for most parameters is in the "Rocky Mountain States Implementation of the Clean Water Act" module. This module shows how the data are compared to the criteria in the water quality standards in each of the Rocky Mountain states**.**

More About Reference Site Comparisons

If you have identified reference sites, you're trying to establish whether your assessment sites are different than or similar to your reference sites. The challenge is to determine what constitutes "different." There are a number of ways to do this depending on the type of data you are using.

You are basically trying to establish your own definition of what constitutes a difference in results over space (site-to-site) or time (each site over time). This requires establishing "typical" values or ranges of values considered "normal" or "background." This is essentially how the ecoregion guidelines were established. If you have one or more reference sites, however, you can use those results as your basis for comparison.

You do not have clear benchmarks and are looking for patterns in your data to gain a better understanding of how conditions vary over time and space.

Each of these requires a different approach. These are described below.

Use the Criteria in the Water Quality Standards and the Established Methods Specified in 305b Guidance

If your plan is to use the criteria in the water quality standards as benchmarks and you expect the state water quality agency to use your data for their 305b assessments (which determine use support) then you must use their comparison methodology, unless you're simply giving them the data.

The comparison results in an assessment of use support status and, ultimately, a determination of impairment. Do water quality conditions support the uses assigned? If the results "meet" the criteria, the uses are supported and the water is not impaired. If the results "exceed" the criteria, the uses are not supported and the water may be impaired. Note that the term "exceedance" does not mean "greater than." It means that the results do not meet the criteria.

Comparisons within your data set

In this case, you can do any number of comparisons to get at your questions:

For a Condition and Trend Assessment:

- Compare results with those at one or more reference sites (minimally affected by human activities) that represent each type of water body from which you collected samples.
- Compare results seasonally and over multiple years for lake trophic parameters: Secchi disk, total phosphorus and chlorophyll a.

- Compare results between Secchi disk, total phosphorus and chlorophyll a

For an Impact Assessment:

- Compare results for one parameter at a control site above and impact and recovery sites below a stressor source for a single sampling event
- Compare one parameter to another at control, impact, and recovery sites that bracket a stressor source.
- Compare results for one parameter control, impact, and recovery sites that bracket a stressor source over time (e.g. season, year-to-year, over a 10-year period)

Summarizing Your Water Column Data Using Simple Statistics

Statistics are simply descriptions of a set of data. Using some simple statistics, you can reduce the volume of data to relatively few numbers that summarize the data set. These statistics are designed to summarize your data in two main ways:

- By giving you values which are representative or typical of the data set
- By giving you the range or spread of your data set , which tells you something about its variability.

Commonly used statistics include *averages* (known as arithmetic means), *geometric means*, *medians*, *ranges* and *quartiles*. Be aware, however, that these summaries become highly un-representative of your data with just a few data points. ***A minimum of five data points is recommended to calculate any of the statistical summaries.***

Your study design should describe which statistical summaries you will use to reduce your data set to a manageable size. Following is a brief definition of each type of statistical summary:

Average (Arithmetic Mean)

Averages take the sum of all the values in your data set and divide it by the total number of values to get a value that is representative or typical of the rest. Averages are especially useful if you know that the variation in your data is relatively low and you don't want to show all of the numbers. For example, you might want to present the average size of a certain species of fish caught at a particular location. Just remember that very high and very low numbers (outliers) can greatly affect the average value and potentially distort the findings. You might choose to leave either really large or small fish out of the average and describe them separately (using additional information to help explain their size difference).

Median

Medians are frequently more representative than the average because the median is the value in the center of a set of values arranged from lowest to highest. This means that half of the numbers are greater than the median and the other half are less than the median. If the set has an even number of values then, the median is the average of the two central values:

13.1 13.6 15.3 25.1 26.5 **32.6** **35.4** 45.3 48.5 52.2 136.7 151.6

The median is 34, the average of the two central values.

The median is more representative especially when the set contains one or two very high or low numbers because changing the magnitude of any of the other values won't affect it at all, as long as they don't change their position in the line up.

Range (Maximum and Minimum)

The range is the difference between the maximum value and the minimum value in your data set. If the difference is large (a wide range), it means that there is a lot of variation in your data. This is useful information when you're trying to determine if there is a trend over time or space because it will give you an idea of the amount of variation that typically occurs. The maximum and minimum values themselves may also be important. For example, dissolved oxygen standards are frequently expressed in terms of minimum concentrations that will support fish. Bacteria levels are expressed in terms of maximum levels that will pose an acceptable risk to public health.

Quartiles and the Inter-quartile Range

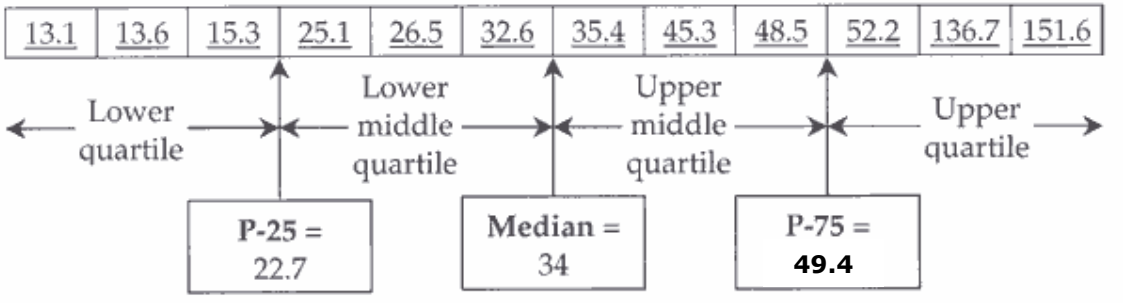
Quartiles describe the range of values around the median. Quartiles use the median to split each half of the data set into half again, just like a dollar can be divided into 4 quarters (see the "Graphs" section below for a graphical example). In effect, quartiles show you the typical value and the range of 50% of your data. By trimming the highest 25% and lowest 25% of your data, you eliminate the influence of the outliers, which may not be representative of the bulk of your data.

The 3 values that are the divisions between the quartiles are called percentiles:

- the ***median*** (or 50th percentile) divides the data in half,
- the ***25th percentile*** (aka P-25) defines the upper boundary of the lowest 1/4 of the number of values in the data set, and
- the ***75th percentile*** (aka P-75) defines the lower boundary of the highest 1/4 of the number of values in the data set.

The ***inter-quartile range*** is the P-75 minus the P-25, essentially, the range of the middle 50% of your data set. If these values are close together (a narrow range), it means that your data set is relatively consistent and clustered around the median. If they are far apart (a wide range), it means that there is a lot of variation in your data. This measure of variation is useful information when you're trying to determine if there is a trend over time or space. Many computer applications calculate quartiles for you, but it's important to understand what the numbers mean.

Here is a set of results for total suspended solids (in mg/L). First the data are arrayed lowest to highest. Quartiles and percentiles are identified based on their values and where they lie in this array.



Monitoring and Assessment Design Workbook

In this data set, the P-25 is calculated from the two values it lies between: (15.3) and (25.1). Excel calculated the P25 for this data set as 22.7. The median is the average between the two central values (32.6) and (35.4). In this data set, the P-75 is calculated from the two values it lies between: (48.5) and (52.2). Excel calculated the P25 for this data set as 49.4.

Geometric Mean

Like the median, the geometric mean reduces the influence of the very high and very low numbers on the data set. To calculate it, a set of data is transformed to the logarithmic values of each data point. These values are averaged (summed and divided by the number of values) and then transformed back to the original units. It is commonly used to summarize bacteria data, since many state water quality standards are expressed in terms of the geometric mean of sampling results taken over a 30- or 60-day sampling period.

Which Simple Statistics To Use?

Which measure you use depends upon the type of data you are summarizing.

In general, we recommend the following summaries for different types of water column data, but you should check local and historical data sets to see how they have been summarized:

Indicator	**Summary**
Temperature (water or air)	* Seasonal average * Seasonal median * Maximum * Range * Quartiles
Dissolved Oxygen (as mg/l)	* Seasonal median * Minimum * Quartiles
DO (as % saturation)	* Seasonal average[1] * Seasonal median * Quartiles
Water Clarity	* Seasonal average * Seasonal median * Maximum and minimum * Range * Quartiles
Bacteria (water contact safety)	* Geometric mean * Quartiles
Turbidity	* Median * Maximum * Quartiles
Nutrients (e.g. nitrate or phosphate)	* Median * Quartiles
Specific Conductivity or Salinity	* Average2 * Median * Quartiles

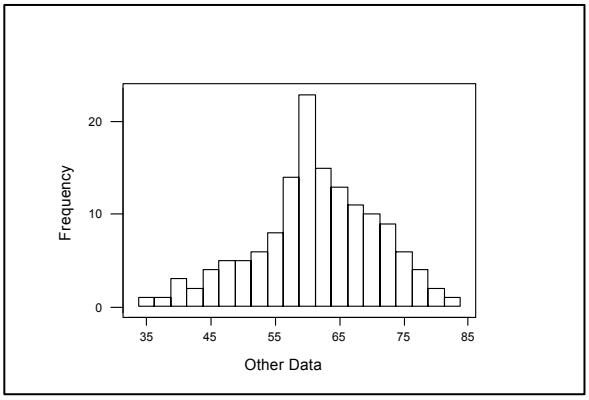
[1] Since % saturation is corrected for temperature and salinity fluctuations, this may be fairly stable allowing you to use the average.

[2] Salinity in estuaries may be fairly stable allowing you to use the average.

pH	* Median or average3 * Quartiles * Minimum
Alkalinity	* Median * Quartiles * Minimum
Chlorophyll a	* Seasonal average * Range * Maximum and minimum * Median * Quartiles

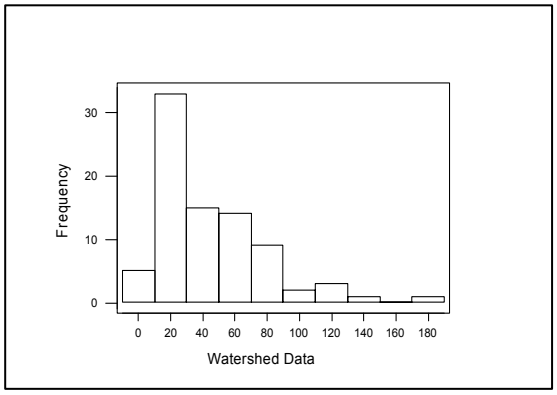
Choosing the correct statistics - Data distributions

The distribution of data is how many times specific values occur in your data set. It's best visualized as a graph with the 'x' axis being the values you measured (e.g. mg/l total P) and the 'y' axis being the number of times each value occurs in the data set.



Normal (Parametric) Distribution

- Approximates a bell-shaped curve
- Measures of central tendency (e.g. average) are not heavily influenced by a few extreme outliers,
- Measures of spread (e.g. the inter quartile range) work (standard error works well here.



Non-normal Distribution

- Curve is "leaning" (*skewed)* to one side. This one is leaning to the left.
- The average is heavily influenced by a few extreme outliers, as is any statistic based on it. The median and the geometric mean are not.
- Sample variance and standard deviation do not work well.

3 The average is acceptable in well-buffered systems (especially estuaries) where fluctuations are not extreme. It also is acceptable if you measure pH to the nearest 0.1 unit. If you measure to the nearest 1.0 unit then use the median.

Summarizing Your Aquatic Life Data Using Biometrics

The numbers of plants or critters in various taxonomic groups are frequently summarized using metrics that represent different aspects of the part of the community. Some of the statistical summaries used for core indicators can also be used on the metrics values, especially when you have more than 5 years of data. Individual metrics that respond in a predictable way to watershed stressors are frequently combined into a ***multi-metric index***.

Benthic Macroinvertebrate Metrics

Metric Category	Definition	Examples
Richness Measures	The number of distinct taxa in the sample	Total # of taxa, # of EPT taxa, # of mayfly taxa
Composition Measures	The percent of the sample in selected taxa.	% major groups, % EPT, % mayflies, % dominance
Tolerance/intolerance measures	Represent the relative sensitivity to perturbations	Biotic index, # of intolerant taxa, % tolerant organisms
Feeding Measures	Balance of feeding strategies in the sample (e.g. predators, grazers, shredders, collectors)	% in each feeding group
Habit Measures	Describe the behavior and adaptations	# of clinger taxa, % clingers
Life Cycle Measures	Describe the length of life cycles	% multivoltine (short), % univoltine (long)

Fish Metrics

Metric Category	Definition	Examples
Richness Measures	The number of distinct taxa or groups in the sample	Total #, # of natives, # of salmonid age classes
Number and Identity of Species	Diversity and identity of indicator species	Darters, sunfish, suckers, green sunfish
Number of Intolerant Species	Number of species that are intolerant of chemical and physical perturbations	# of sensitive species, % cold water species
Feeding Measures	Balance of feeding strategies in the sample (e.g. insectivores, omnivores, carnivores)	% in each feeding group
Abundance Measures	The number of individuals in the sample	Density, % abundance of dominant species, biomass
Reproductive Measures	Measure of the suitability of the habitat for reproduction	% hybrids, % introduced species, % native species
Disease Measures	The percent of the sample that shows evidence of disease	% of individuals with deformities, eroded fins, lesions, tumors

Periphyton Metrics

Metric Category	Definition	Examples
Abundance Measures	Represents the amount of production	mass, ash-free dry mass, chlorophyll a
Richness Measures	The number of distinct algal species in the sample	# of diatom species, # of soft algae species, total # of genera, total # of divisions
Composition Measures	The percent of the sample in selected taxa or groups.	Shannon Diversity, % specific taxa, % live diatoms
Pollution Tolerance Measures	Represent the relative sensitivity to perturbations	Pollution Tolerance Index, % sensitive diatoms

Which metrics you can calculate depends on whether you used quantitative or qualitative collection methods and to what taxonomic level you were able to identify the critters. Individual metrics are frequently combined into a multi-metric index. These are calculated by applying some sort of scoring system to the individual metrics results and adding the scores to come up with a total score or index. Examples include the EPA's Total Metric Score in the Rapid Bioassessment Protocols, Ohio's Invertebrate Community Index or Karr's Benthic Index of Biotic Integrity. Total scores or indexes for each site may then be compared with scores or indexes for regional or upstream reference sites. Reference sites are minimally impaired sites which are similar in most characteristics (especially habitat) to the sample site. Some approaches produce a percent comparison to the reference site by dividing the score or index for the monitored site by the score or index for the reference site.

Summarizing Your Physical Habitat Data

Geomorphology: This includes various measurements of the stream bottom, the depth to which the stream has carved its channel, channel width/depth ratio, sinuosity (meandering pattern), number of channels, slope. These data can be summarized in several ways:

- **Stream Classification**: There are various systems that use the basic data to divide streams into different types.
- **Channel Evolution Models**: Describe the sequence of changes a stream undergoes after certain kinds of disturbances.
- **Proper Functioning Condition**: This is a methodology for assessing the physical functioning of a streamside wetland area. The result is an assessment that places an area into one of 3 categories: proper functioning, functional-at-risk, or nonfunctional.
- **Stream Stability**: This summarizes data to assess whether a given reach is stable and, if not, whether its just a local condition or stream system-wide.

Flow: Flow (aka "discharge") data describe the volume of water passing by a particular location over some time interval. At the simplest level, flow data are typically summarized as cubic feet per second. Other types of flow summaries include:

- **Flow Duration**: This is the amount of time certain flow levels exist in the stream. This is usually expressed as the percentage of time a given stream flow of interest (e.g. drought or flood flows) is equaled or exceeded over a given period. These are summarized using "flow duration curves.
- **Flow Frequency**: This is the probability (or a percent chance) that a given flow will be exceeded in a given year. These frequencies are determined by applying statistical methods to a long-term set of flow data. The flows of interest are usually one or all of the following:
- **Flood frequency**: the probability that given flood flows will occur in a given year.
- **Low flow frequency**: the probability that given low flows will occur in a given year.
- **Channel-forming flow**: This is actually a variety of theoretical flows that maintain the geometry of the channel. Common measures are the bank full discharge, effective discharge, mean annual flow, etc.

Substrate Quality: The substrate is the bottom of a water body. Quality refers to its usefulness for various biological functions, such as attachment, shelter from the current, shelter from predators, spawning, rearing, etc. It is usually based on an inventory (aka "pebble count") of the number of particles in various size classes, such as bedrock, boulders, cobble, gravel, and, silt, and organic material. The most common summary technique is a size distribution. This plots the different particle sizes according to the frequency with which they occur at a given location. These distributions are then related to the requirements of different organisms.

Riparian Vegetation: The data gathered are typically focused on changes and functions of vegetation close to the water.

Summarizing Your Data Using Tables and Graphs

Once you analyze your data using statistics, you begin to be able to comprehend your data set because you've reduced the sheer volume of numbers to a more manageable level. However, there are a few tools available that are more visual – tables and graphs – that can reveal things still hidden in the numbers.

Some people generate hundreds of tables and graphs to help them see patterns and trends. This is very different from using them to communicate results. That's covered in the next step. For our purpose here, we will focus on tools which help you see the data in different ways.

Data Entry Revisited

Most data is entered and/or stored in a format that looks like this:

Site #	Date	Parameter 1	Parameter 2	Parameter 3
Site 1	Date 1	0.07	2.46	14.1
Site 2	Date 1	0.10	4.01	3.2
Site 3	Date 1	0.09	3.21	9.0
Site 1	Date 2	0.04	2.20	13.1

This format allows you to sort by any column or row, which enables you to see the data in various orders. However, the fundamental layout can't be easily changed: column headings and row headings must remain the same.

Say you want to view the data by parameter, with row headings as sites and column headings as dates. That can help you see trends over time and upstream to downstream for a single parameter. Some spreadsheets allow you to do that, and most databases. But you must create that layout.

From this point on, what you can do to manipulate and rearrange the data depends mostly on your software and your ability to get it to do what you want. So, we'll just focus on the basic idea of how you would like your data arranged and displayed so you can come to grips with it. Whether using summaries or not, it may help to creating visual displays of the data to help you understand it, The most frequently used displays are tables and graphs.

Tables

A table presents the numbers in an organized way, typically in columns and rows There are two types of tables we recommend. One displays all of your data. The other shows the statistical summaries of this large data set. Tables that display all of your data should be used for reference, to make data available that are obscured when displayed in graphs or summaries. These might be quite large and complex.

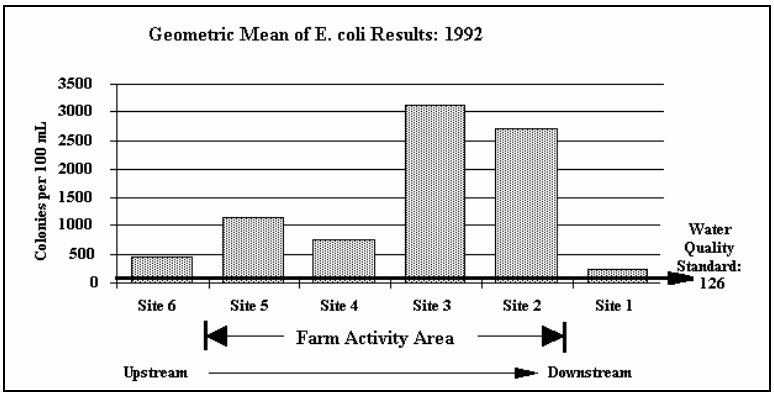
A good table has . . .

- readable, logical data placement
- clear column and row headings
- a title at the top
- reporting units

Graphs

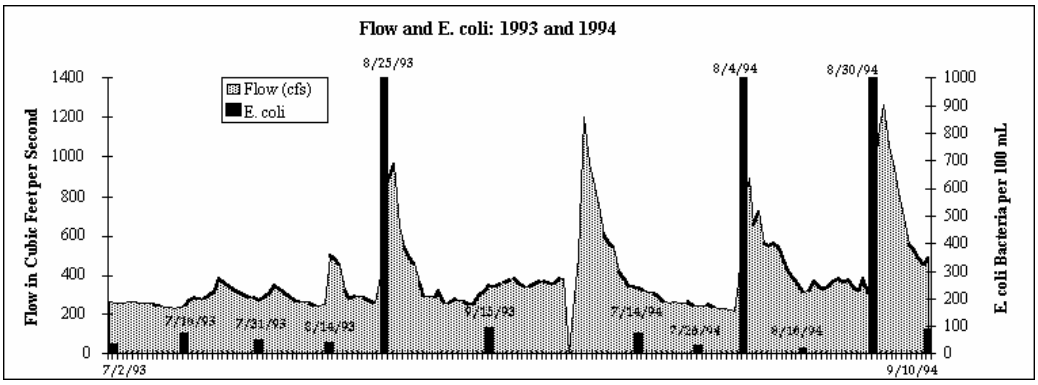
Often, patterns in the data can be easier to see in a graph. This section describes a few of the many types of graphs you can use to help you understand your data (as opposed to using graphs to communicate with an audience). In this case, the audience is you!

Example 1



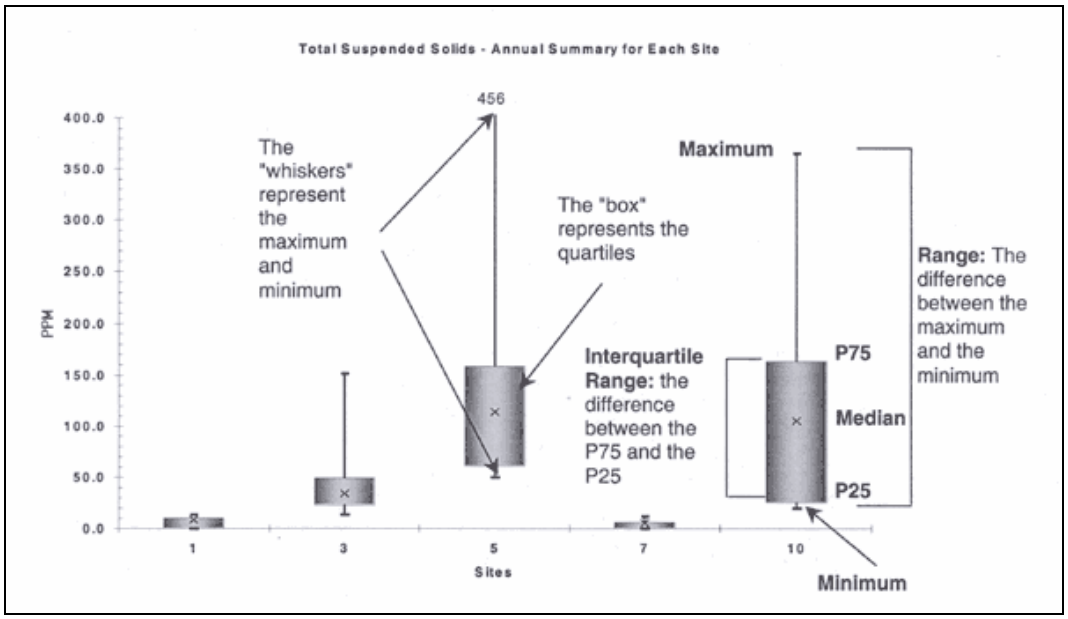
For example, this bar graph compares the geometric mean of one indicator to: 1) the same indicator at different sites and 2) a water quality standard. You can easily see at a glance that the highest bacteria levels in 1992 were consistently at Sites 2 and 3. It also shows you that all sites except Site 1 were usually higher than the water quality standard.

Example 2



As you can see in this combination graph, you could also compare how one indicator relates to: 1) another indicator and 2) over time. Here is a combination of E. coli results (bars) compared with flow (gray area). Like a line graph, the gray area emphasizes either a relationship or a trend among data points, rather than individual data points. A word of caution: emphasizing the continuity and relationship between data points implies that you know the relationship between the values found at each site. This may or may not be the case so line or area graphs can be misleading unless you have enough data points to feel confident that the trend implied is valid. In the case of the flow example here, this is appropriate, since these are average daily flows and thus, "continuous" measurements.

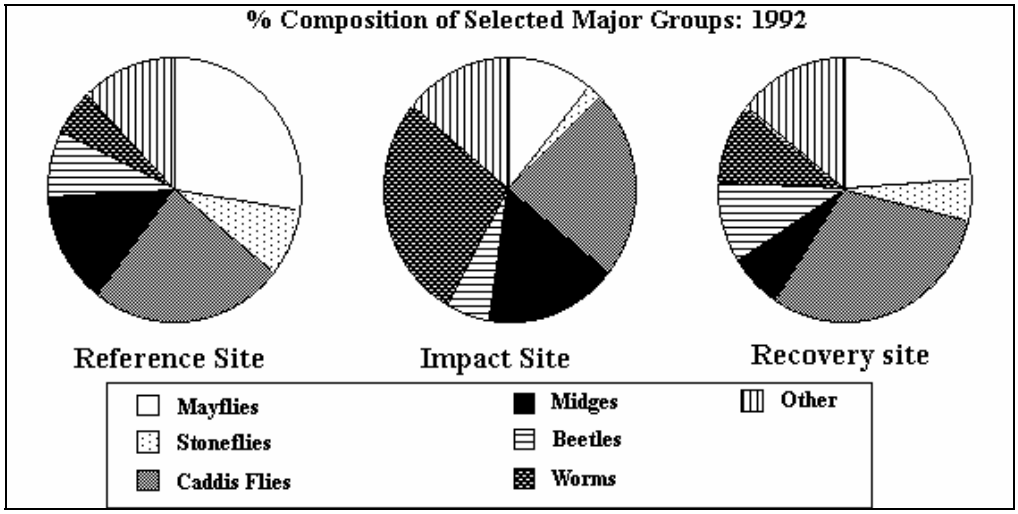
Example 3



You may also want to look at the variability of your data and whether there are meaningful differences among the results at your samples sites. In this case, a "box and whisker" plot showing the quartiles and inter-quartile range might be helpful. This sample "box and whisker" plot shows you that the results varied most (largest range and inter-quartile range) at Sites 5 and 10 and least at Sites 1 and 7.

The more overlap of the "boxes" (the inter-quartile range) between two sites, the more confident you are that the results are similar. If your analysis involves a comparison between assessment sites and reference sites, this is a relatively simple way to actually "see" the difference or similarity. If there is little or no overlap, there is likely a meaningful difference. For example, the inter-quartile ranges for sites 5 and 10 overlaps between 60.0 and 158.0 mg/l. This is very easy to see just by looking at the boxes. In contrast, the inter-quartile ranges for sites 1 and 5 don't overlap at all.

Example 4



Pie charts, like this example, are commonly used to show percent composition of the data. They easily display the percentage of a sample or a data set that is composed of different groups. For example, they can show the percent of a sample that is composed of different water quality indicators, pollution sources, or taxonomic groups. They can show the percent of the total number of samples that fell within certain ranges.

Develop Findings

Findings are observations about your data. They are the statements that summarize the important points but do not explain them. We tend to look at data and then begin to try to explain it before thoroughly observing and summarizing the trends, patterns or lack of patterns. Findings should support your conclusions.

For example, let's look back at the sample "box and whisker" plot. Let's assume that site 1 is the reference site and we are using a criterion, which says, that sites with inter-quartile ranges that don't overlap with the reference site are significantly different. Your findings could be:

- the site most like the reference site is site 7,
- the sites least like the reference site are sites 5 and 10 (though they are quite similar to each other), and

In order to help you develop findings, look for patterns within your data set as well as comparing your results to reference conditions, you might answer any of the questions listed below.

Quality Control Questions to ask of your data set

- Did you collect the required number of samples from the minimum number of sites (completeness)?
- Did you collect samples frequently enough, at the right time of year, at the right time of day to be representative of the conditions you are assessing?
- How did your quality assurance results (from split, duplicate, spiked, replicate, known, unknown, and blank samples) compare with expected results? Did they meet your data quality objectives?

General questions to ask of your data set

- Which sites had the highest or lowest readings?
- Which dates had the highest or lowest readings?
- Which tidal stage had the highest or lowest readings?
- Are there numbers that seem to be much higher or much lower than typical results ("outliers")? Are you confident that these numbers are reliable? Verify that the numbers were transcribed or entered correctly.
- Do your results show a consistent pattern of change upstream to downstream or close to and further from the impact source? Do levels increase or decrease in a consistent manner?
- If you are monitoring the impact of a pollution source, for example, are your results different above and below the impact or at different tidal stages?
- Do changes in one indicator coincide with changes in another? As illustrated earlier, there is usually an inverse relationship between water temperature and dissolved oxygen, since warm water can hold less oxygen than cold water. There's a similar relationship between an increase in water column algae and a decrease in water clarity.
- How do your results compare among tributaries?

Questions to ask of your data when comparing them to benchmarks / reference conditions:

- **Comparisons with maximum and minimum**: Did the results exceed the maximum and minimum acceptable levels set by the tribe. Where? When?
- **Comparisons with ranges**: Were the results inside or outside of your acceptable range? Where? When?
- **Comparison with allowable number of times that results did not meet your reference conditions**. Your reference conditions or your assessment procedure might specify a maximum number of times, or percent of the time, when results do not meet standards. How many times (or what percent of the time) were reference conditions not met? Where? When?
- **Sampling dates**: Are there sampling dates when most or all results did not meet your benchmarks?
- **Special weather or hydrologic conditions**: Were there any conditions (dry or wet periods; large or long precipitation events; tidal stage; wind conditions; day of the week; time etc.) when most or all results did not meet your benchmarks?

- **Percent Similarity**: This is the similarity of the assessment site to the reference condition. Developing a finding about what the resulting percentage means usually involves some sort of guidance. For example, here's a guideline that could be used to evaluate the percent similarity for benthic macroinvertebrates:

  >79% Non-impaired: Comparable to the best situation expected within an ecoregion. Good representation of pollution intolerant organisms. Optimum community structure compared with reference.

  29-72% Moderately Impaired: Partly comparable to the best situation expected within an ecoregion. Community structure shows decrease in richness and pollution intolerant organisms.

  <21% Severely Impaired: Not comparable to the best situation expected within an ecoregion. Low richness, dominated by few families.

Add info on quality control samples and associated data.

Case Study 1

Case Study 2

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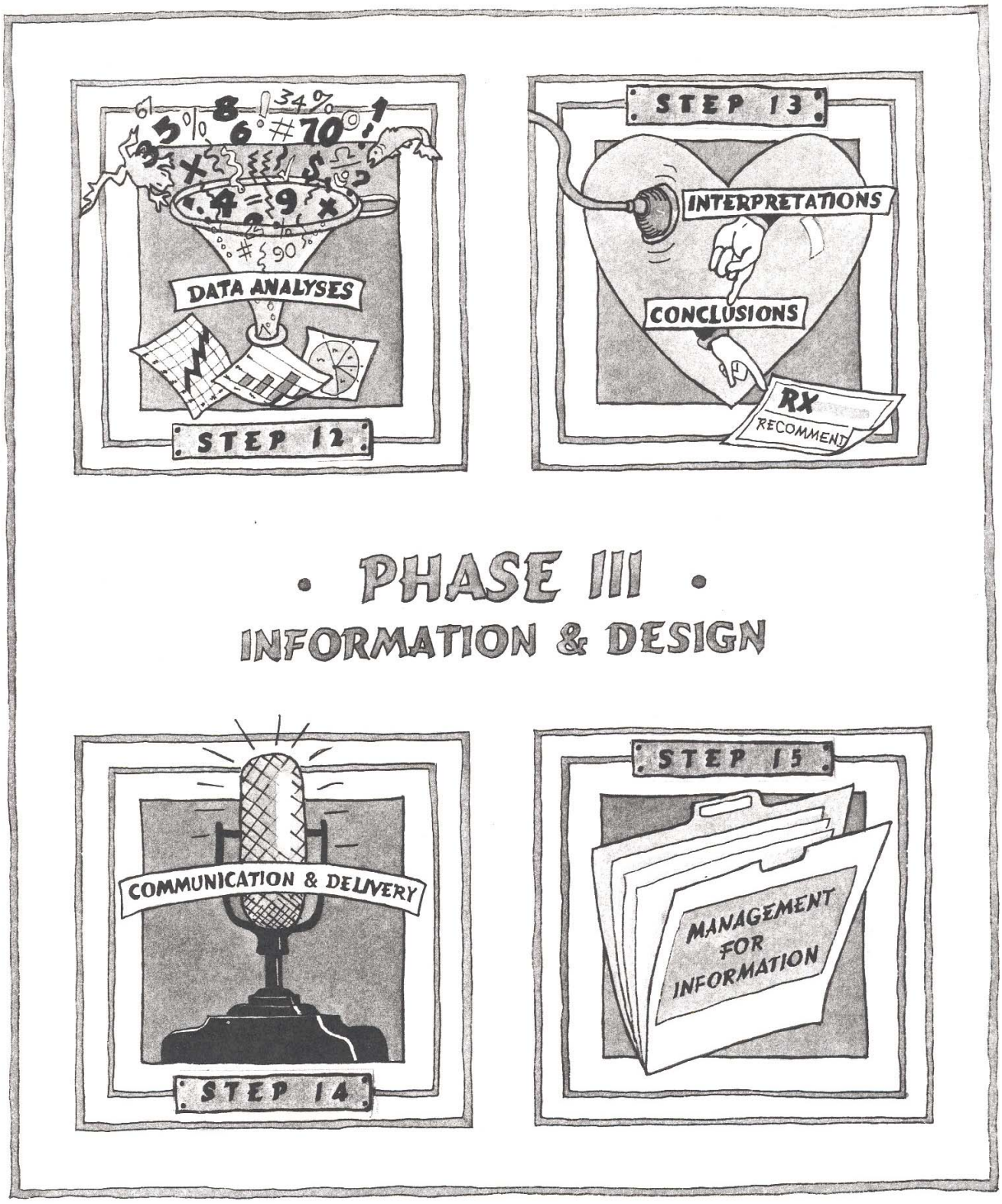
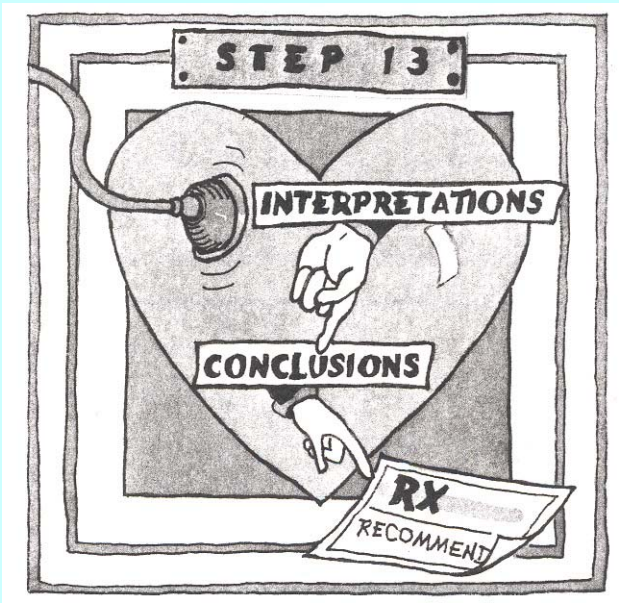
Resources



Step 13: Data Interpretation and Conclusions



"He who cannot change the fashion of his thoughts, cannot change his reality and will not make progress."

Anwar Sadat

About This Step – *This step is designed to accomplish 4 things:*

1. Help you plan to interpret the comparisons to your reference conditions that you identified back in your information blueprint (step 6).
2. The process you will use to draw conclusions as to whether there is a significant change from what you expect in a healthy water body (your reference conditions) over time and space.
3. The process you will use to determine that, if there is a significant change, what might be causing it and what are the sources.
4. Prepare you to produce a report with findings, conclusions, and recommendations

Why Do This Step

Interpreting your data and developing conclusions is the heart of watershed assessment. Interpretation is often an uncomfortable leap for some. It is, in fact, the "assessment." So, unless you do this step, you produced a data summary or even a report with a set of findings. But, until you venture into the realm of interpretation, assessment or opinion (hopefully supported by the facts), that answers your monitoring questions and achieves your monitoring reason, you have not actually done an assessment.

So, this step is critical. It's where you will decide how you will pull the information you've generated together and try to find the story.

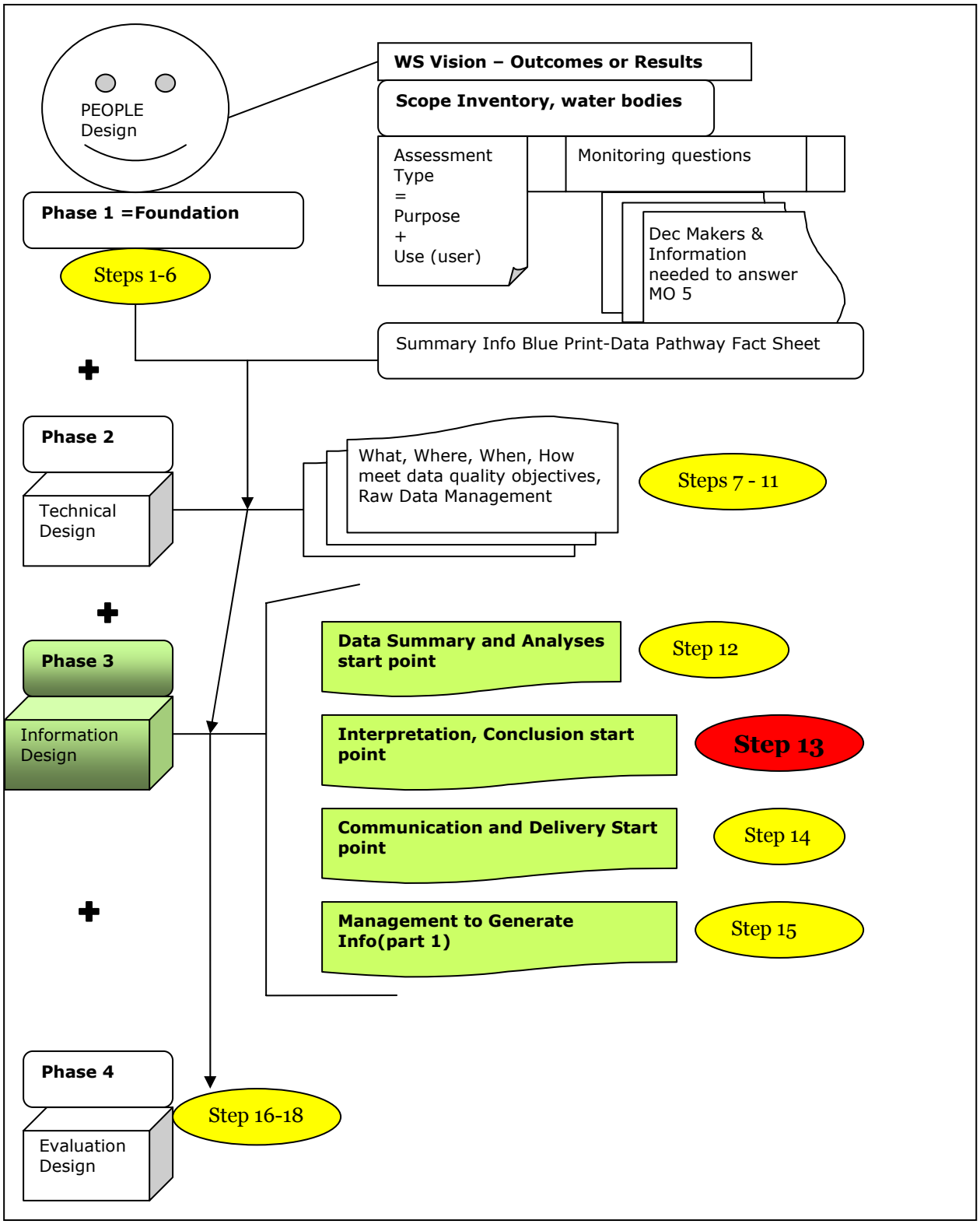
Where are we in the Big Picture Illustration?

Phase 1	Step 1: Share Watershed Vision and Desired Outcomes (Results) Step 2: Scope Inventory (Physical, People and Information) Step 3: Identify Monitoring Reason(s) and Data Use(s) (Assessment Type) Step 4: Develop Monitoring Questions (Refinement of Monitoring Reason) Step 5: Target Decision Makers and Info Needs (Refinement of Data Use) Step 6: Summarize with Information Blue Print-Data Pathway Fact Sheet)
Phase 2	Step 7: What Will You Monitor? Step 8: When Will You Monitor? Step 9: Where Will You Monitor? Step 10: How Will You Monitor to Meet Data Quality Objectives? Step 11: Management of Raw Data (Data Management Plan Part 1)
Phase 3	Step 12: Data Summary and Analysis **Step 13: Interpretation, Conclusions and Recommendations** Step 14: Communicating and Delivery Step 15: Management to Generate Info (Data Management Plan Part 2)
Phase 4	Step 16: Who Will Do What? Task Identification Step 17: Evaluation of Effectiveness (of Plan and Implementation) Step 18: Documentation and Communication (of M & A Plan)

Products (see Figure Phase 3 Product List):

- ✓ A data interpretation plan that is your "starting point", it includes your methodology for interpreting your data and producing a set of conclusions that address your monitoring questions.

Phase 3 Product Illustration:



What Should Be Done Before This Step

The results from Phase 1 or the people orientation provides the foundation for Phase 2 Steps. Thus, ideally you need to have identified a watershed vision and desired outcomes with associated assumptions and external factors. Defined combination of monitoring reasons and uses, we call Assessment types. For each assessment type a list of monitoring questions the data is to answer and how that question will be answered.

For each monitoring question, a list of targeted decision makers, their decision, how they make that decision and what information they need to make the decision. A format to document and summarize the results, we have suggested the information blueprint. If your decision maker has a mechanism to analyze and interpret/assess the data then you have your starting point for this step, just document it. If not then this step helps you define that starting point.

The results from Phase 2 Steps, provide the foundation for Phase 3 Steps. Steps 7-9 identify indicators, characterize frequency, and identify sites that will answer monitoring questions. Step 10 identifies and documents methods, data quality objectives and quality control procedures necessary to make the desired decisions. Step 11 defines how raw data will be managed to be ready for Phase 3, turning that raw data into information to be delivered.

From Phase 3, Step 12 you have:

- ✓ An identified method for comparing your quality control data to your data quality objectives.
- ✓ Benchmarks established for each parameter
- ✓ A methodology for comparing your data to each of the benchmarks
- ✓ The statistical measures you will use to summarize the central tendency and variability of the data.
- ✓ A set of questions you will ask of your data to develop findings and conclusions.

Basic Tasks

Basic Tasks are numbered to correlate with the overall 1-18 Steps provided in these guidance modules followed by the basic task sequence step to complete. For example Step 4, basic task 2 would be numbered as Basic Task Step 4.2, Step 3.3 correlates to Step 3, Basic Task 3.

 13.1 Identify who will make the decisions about this step and who should be involved in the planning process (they may be different).

 13.2 Self Assessment: If you've been monitoring before you've undertaken this process, has your data analysis worked well?

 13.3 List the existing information from your inventory and which of your data summaries, you will use to answer each of the monitoring questions and for each assessment type you listed on worksheet 4.3.a (Step 4).

 13.4 Describe the process by which you will develop a set of conclusions that might explain your findings and the extent to which you can answer your monitoring questions.

 13.5 Outside Data Review: Review the data and your interpretation of it with an advisory group or technical committee This group should involve local, regional, and state resource people who are familiar with monitoring and with your waterbody. They can verify, add to, or correct your interpretation of the results.

 13.6 Develop a set of recommendations for future monitoring and (if appropriate), actions to protect and/or restore your waters.

 13.7 Update *Data Management Plan Part 1*. See provided outline in Step 11, edit or develop your own for these items.

 13.8 Update *Inventory Master List* and *Plan.*

 13.9 Update *Information Blueprint – Data Pathway Fact Sheet* for each monitoring question.

 13.10 Place Products in your *Watershed Monitoring and Assessment Plan*.

 13.11 Place your identified gaps and needs regarding this step in the *Action Plan* (what you need to plan to complete this step and or overall monitoring and assessment plan).

Worksheets

Work sheets are listed below. Not all Basic Tasks have an associated work sheet. To simplify completion of products for each step, the worksheets or broken into small subsets of tasks. This requires moving the results of one task into the next task and will seem redundant, especially if completing worksheets by hand. Worksheets are provided in word here for ease of reproducibility. These are a starting point, we encourage you to customize these and reproduced them in an electronic format, in Excel for example, where it is easy to move information from one area to another by cutting and pasting.

Work Sheets are numbered to correlate with Basic Steps and the overall Steps in these guidance modules. Each consecutive work sheet is lettered a, b, c and so forth , preceded by the Basic Task sequence step, preceded by the Step number. For example, Worksheet Step 4.2.a and Step 4.2.b, correlates to Step 4, Basic Task 2, Worksheet a and Worksheet b. In theory worksheet a needs to be completed before worksheet b.

Worksheet 13.2.a	**Self Assessment Step 13 Worksheet and Products to be completed Prior to this Step, Part 1 and Part 2**
Worksheet 13.3.a	**List the existing information from your inventory and which of your data summaries, you will use to answer each of the monitoring questions and for each assessment type you listed on worksheet 4.3.a (Step 4).**
Worksheet 13.4.a	**Describe the process by which you will develop a set of conclusions that might explain your findings and the extent to which you can answer your monitoring questions.**
Worksheet 13.10.a	**Place Products in your *Watershed Monitoring and Assessment Plan.***
Worksheet 13.11.a	**Place your identified gaps and needs regarding this step in the *Action Plan* (what you need to plan to complete this step and or overall monitoring and assessment plan).**

How to do Worksheets

For Sheet 13.2.a Self Assessment Step 13 Worksheet and Products to be completed Prior to this Step, Part 1 and Part 2

Part 1. Complete the self assessment section of the worksheet to evaluate what you have or what decisions have already been made. This will help you focus on what you need from this step and incorporate valuable existing information or products into this plan.

Part 2. Next, to prepare to complete this step the following, you need to have the following items addressed:

- ✓ Desired set of outcomes or results that the monitoring and assessment activities will be designed to help achieve
- ✓ Identified monitoring and assessment activities, specific combinations of a monitoring reason plus an associated data use; we call this an Assessment Type. You may have multiple Assessment Types.
- ✓ For each Assessment Type, the list of specific monitoring questions the monitoring and assessment will be designed to answer.
- ✓ For each monitoring question, the targeted decision makers, the type of decisions they will make and the information they need to make them (as specific as possible).
- ✓ A minimal scoping inventory that identifies the watershed boundary and water bodies you are focusing on (rivers, lakes or wetlands), physical attributes of water bodies (including status, uses, etc.), relevant cultural or historical aspects, existing data sets or monitoring efforts and others in the watershed who either you want to influence or could help you implement.
- ✓ Technical sample plan including what monitor (indicators, benchmarks, criteria, etc.), where and when monitor, how will meet data quality objectives (methods, how good does the data need to be for decision makers, quality assurance and control measures), and how will manage and verify raw data/information.
- ✓ Plans for data analyses and developing findings

This is the ideal list, if you do not have any of these, they become a gap or need that should be addressed before any data is collected or analyzed, even if the answers aren't perfect or you don't have a large degree of confidence surrounding them, they should be attempted as the starting point. This is what you are evaluating in this step-your monitoring and assessment plan.

Worksheet 13.2.a Self Assessment Step 13 Worksheet and Products to be completed Prior to this Step, Part 1.

Part 1 Self Assessment of Known Evaluation Products and Processes

1. **Determine if you "have" or "don't have" the item, mark the appropriate box. If you don't have it and determine you don't need it, explain why in the comments document. You may not need to know but perhaps your target decision makers, board or membership might want to know.**

2. **If you have the item "documented", mark that box. If so, list in the comments where, hard copy, chapter in a document, electronic file name and location, etc. The assumption is you value the ultimate goal to document and communicate your M & A plan, activities and results.**

3. **If you have the item, assess the use of it, use the scale below or provide your own answer and comments.**

   Rating Scale for USE:

   0=doesn't exist so use is nil
   1=don't know why would need or understand item
   2=exists, don't know where it is, if it is used, etc. so use is essentially nil
   3=exists and use some of time
   4=exists and use all the time
   5=wish it existed, would use it lots

4. **If you have the item, assess the effectiveness of it, just because something exists or is used does not mean it is effective in its use, use the effectiveness scale below or provide your own answer and comments.**

   Rating Scale for EFFECTIVENESS, assumes material exists:

   0=not effective or functional at all
   1=incomplete (all elements are not there) and some existing parts need revising
   2=incomplete but what is there is okay
   3=complete (all elements are there), some parts okay but need revising
   4=complete and effective

Item	Have	Don't Have	DOC	Assessment of Use (Scale 0-5)	Assessment of value / effectiveness (Scale 0-4)	Comments/Notes
42. Starting point for data interpretation, conclusion, recommendations plan for each indicator used, first cut at what will do.						**Phase 3 Step 13**

*DOC=Documentation, *M & A= Monitoring and Assessment

5. To make this assessment useful, determine what your gaps and needs are regarding this step in order to focus your effort in completing this step.

Worksheet 13.2.a Self Assessment Step 13 Worksheet and Products to be completed Prior to this Step, Part 2.

Part 2 Products to be completed before this step, in order to complete this step

Item	Response
Desired set of outcomes or results that the monitoring and assessment activities will be designed to help achieve:	
Assessment Types, specific combination of one monitoring reason and data use(r):	
For each Assessment Type, the list of specific monitoring questions:	
For each monitoring question, the targeted decision makers, the type of decisions they will make and the information they need to make them (as specific as possible):	
Watershed(s) and Water bodies of focus:	
Physical attributes of Water bodies (status, use, etc.)	
Existing Data or monitoring efforts:	
Indicators, benchmarks and criteria list:	
Characterization of monitoring frequency:	
List of monitoring locations/rationale:	
Methods list, list of data quality objectives (methods, how good does the data need to be for decision makers), quality assurance and control measures)	
Plan for raw data management and support mechanisms:	
Monitoring results summarized using statistics, graphs and tables.	
The results of your comparison of your data with your benchmarks summarized	
The results of your comparison of your QC data with your data quality objectives	
A method to develop a set of findings from the data set	

For Sheet 13.4.a **This worksheet describes the process by which you will develop a set of conclusions that might explain the your findings and the extent to which you can answer your monitoring questions.**

Column Headings Defined

Assessment Type: Refer back to step 4 and worksheet 4.3.a. List one or more of the following 4 assessment types , or whatever type you are using:

- **Condition Trend**: Is there a change from existing conditions in XYZ? Is there a change from historic or reference conditions? Is there an unacceptable deviation from ABC criteria? What are limiting factors?
- **Impact**: Is waterbody A affected by landuse practice B?
- **Effectiveness**: Did restoration/BMP Y work? If so why, if not why not?
- **Use Support**: Is it safe to swim in waterbody X? Are fish dying in waterbody Y? What is desired or potential condition?

Overall Monitoring Question: This is restating your assessment type as a question. To continue with the example we used in Step 4.3:

- **Condition and Trend**: Is there a change from existing conditions in XYZ? Is there a change from historic or reference conditions? Is there an unacceptable deviation from ABC criteria? What are limiting factors?
- **Impact**: Is waterbody A affected by landuse practice B?
- **Effectiveness**: Did restoration/BMP Y work? If so why, if not why not?
- **Use Support**: Is it safe to swim in waterbody X? Are fish dying in waterbody Y? What is desired or potential condition?

Conclusions: Conclusions are, statements of your interpretation. For each finding, develop a conclusion, if you can (if the results appear to support it). For example:

- **Finding:** 8 of the 10 (80%) samples collected at site RoR10 and RoR12 violated the bacteria in the water quality standards. Since you don't yet have any findings (remember this is just your plan for how to develop them), this table encourages you to think about the *process*.
- **Conclusion:** This reach of river does not support its designed swimming use and is therefore impaired.
- **Reviewed by (date):** Who will review these conclusions and when?

Worksheet 13.4.a **Describe the process by which you will develop a set of conclusions that might explain your findings and the extent to which you can answer your monitoring questions**

Assessment Type:	**Overall Monitoring Question __ of ___:**
Questions you will ask to develop conclusions	**Who will review conclusions**

For Sheet 13.10.a **Place Products in your** *Watershed Monitoring and Assessment Plan*.

- Description and documentation of your interpretation and assessment process, procedures and or plans.

Worksheet 13.10.a **Add products of Step to** *Monitoring and Assessment Plan.*

If you completed any Steps this Worksheet is cumulative, use that document. If you have not you complete that aspect that is highlighted for your plan documentation. **Italics mean a sub plan that might be attached or live somewhere else, location of document and contact is what would go in the plan.*

I. People Design, Phase 1

A. Shared Watershed Vision and Desired Outcomes (Step 1)

1. Logic Model of Desired Outcomes/Results and activities/target audiences to employ to achieve outcomes

B. Keepers of the M & A Plan (Step 1)

C. Watershed Boundary (Step 2)

D. Water bodies of Interest (Step 2)

E. Scope Inventory Master List* (Step 2)

1. Physical Inventory * (Step 2)
2. People Inventory* (Step 2)
3. Information Inventory* (Step 2)
    a. Existing Monitoring Efforts (Step 2)
    b. Existing Data Sources (Step 2)
4. Inventory Action Plan* (Step 2)

F. Assessment Type(s) List – Monitoring Reason + Use (Step 3)

1. Monitoring Question(s) (Step 4)
2. Targeted Decision Maker(s) (Step 5)
    a. Information Needs (Step 5)
3. Information Blue Print – Data Pathway Fact Sheet Per Monitoring Question* (Step 6)

II. Technical Design, Phase 2

A. What (Indicators, Benchmarks, etc.) and why? (Step 7)

B. When and why? (Step 8)

C. Where and why? (Step 9)

D. W(how) will meet data quality objectives? (Step 10)

1. Data quality objectives (Step 5 and 10)
2. Quality Assurance and Control Measures (Quality Assurance and Control Plan)* (Step 10)

E. Data Management for Raw Data (Data Management Plan Part 1)* (Step 11)

III. Information Design, Phase 3

A. Data Summary and Analyses (Step 12)

1. Starting Point (Step 12)
2. Changes (Later)

B. Data Interpretation, Conclusions, Recommendations

1. Starting Point (Step 13)
2. Changes (Later)

C. Communication and Delivery

1. Starting Point (Step 14)
2. Changes (Later)

D. Management Plans to Generate Information (Data Management Plan Part 2)* (Step 15)

IV. Evaluation Design, Phase 4

A. Who Will Do What? (Step 16)

1. Task Identification Matrix (Step 16)
2. Communication Structure and Tools (Step 16)

B. Evaluation Plans (Step 17)

1. Evaluation Plans for M & A Components (Step 17)
2. Evaluation Plans for M & A Implementation (Step 17)
3. Evaluation of inter/intra M & A Activities (Step 17)

C. Documentation and Communication (Step 18)

1. M & A Plan (**this document**, updated Sub documents) (Step 18)
2. Communication and Peer Review Plan (Step 18)
3. Action Plan* (Step 17)

For Sheet 13.11.a **Place your identified gaps and needs regarding this step in the *Action Plan* (what you need to plan to complete this step and or overall monitoring and assessment plan).**

Worksheet 13.11.a **Final *Action Plan* Part 1, Summary:**

If you have completed each Step, or for those you have, you have a cumulated list of gaps and needs related to that Step. Use that same worksheet/document. If you did not complete each Step, look at what each Step is supposed to accomplish and record what your gaps and needs are related to that topic. The goals are to get the gaps and needs in one place to evaluate and prioritize.

Phase 1 Step 1: : (completed in Step 1)
Phase 1 Step 2: : (completed in Step 2)
Phase 1 Step 3: : (completed in Step 3)
Phase 1 Step 4: : (completed in Step 4)
Phase 1 Step 5: : (completed in Step 5)
Phase 1 Step 6: : (completed in Step 6)
Phase 2 Step 7: : (completed in Step 7)
Phase 2 Step 8: : (completed in Step 8)
Phase 2 Step 9: : (completed in Step 9)
Phase 2 Step 10: : (completed in Step 10)
Phase 2 Step 11: : (completed in Step 11)
Phase 3 Step 12: : (completed in Step 12)
Phase 3 Step 13: : Interpretation, Conclusion and Recommendations
Phase 4 Steps: Will add Action and Needs as complete each Step and at the end prioritize

Background and Content

This section focuses on how to develop conclusions to answer your monitoring questions as background for worksheet 13.4a.

Describe how you will develop conclusions

Developing conclusions from your findings is not nearly as difficult as developing them directly from the data. We suggest that you consider an open process for coming up with conclusions:

- ✓ Evaluate your data. Did you meet your data quality objectives and those required by your data users?
- ✓ Review the findings "in-house" (e.g. among colleagues within your group) and develop a preliminary set of conclusions.
- ✓ Review of the findings and draft conclusions by a technical advisory committee,
- ✓ Hold one or more public meetings (see step 10) to solicit information, and possibly new conclusions.
- ✓ Produce final conclusions

Getting to a set of conclusions from data summaries usually involves some sort of comparison. Two basic comparisons are 1) did you meet your data quality goals? And 2) is there a change from the reference conditions and is it meaningful? If the answer to the first question is no, then you can't really answer the second.

Your conclusions relate back to your monitoring questions and the type of assessment you are doing. Following are some guidelines to help you develop conclusion for each type of assessment.

Developing Conclusions for 305b Assessments

This process (under section 305b of the Clean Water Act) draws conclusions about whether waters support their designated uses. The parameters are compared with the criteria in the water quality standards, as previously discussed. Depending on the results of that comparison, a conclusion is drawn as to whether or not conditions support designated uses (usually water recreation and aquatic life).

The tables[1] below summarize how the use-support status is determined for each pollutant. The end result is an assessment of impairment:

- **Fully supporting** the use is listed as "fully supporting" in the 305(b) report and does not appear on the 303(d) list.
- **Partial support** of the use means that the river reach or lake is listed as "partially supporting" in the 305(b) report, and it **may** be listed as "impaired" on the 303(d) list.
- **Non-support** indicates an impaired condition and the water body is placed on the "not supporting" list for the 305(b) report, and it goes on the 303(d) list. For some assessments, lake eutrophication for example, the "partial support" category is a trigger for further analysis of that water body until the minimum data requirements are met for making an impairment decision. (if it meets minimum data requirements).
- **Potentially supporting** is used in assessing impairment of swimming use (fecal coliform bacteria). It is also a screening category that triggers further assessment. The agency plans in the future to maintain a list of water bodies for which insufficient data are available to make a complete assessment, but the available data suggest some impairment. This list will help establish priorities for allocating future monitoring resources.

This example is from Minnesota. The states are all similar, but each has its distinctive terminology and methodology.

[1] From MN Pollution Control Agency, 2004. Guidance Manual for Assessing the Quality of Minnesota Surface Waters For Determination of Impairment. 305(b) Report and 303(d) List: Table 18, p. 85. MPCA, St. Paul, MN January 2003.

Table 17. Summary of Data Needed for Water Quality Assessments for 305(b) Report and 303(d) List for Use Support and Impairment Determinations, for Pollutants with Numeric Standards.

Pollutant Category **305(b) Report, or 303(d) List**	**Minimum Number of Values*, and Data Treatment**	**Exceedance Thresholds:** • **Number or Percent Exceedances of Chronic Standards** **Use Support or Listing Category**		
Pollutants with Toxicity-based Standards	Number of Exceedances →	≤ 1	na	≥ 2
305(b)	5 values in 3 years	Fully supporting	na	Not supporting
303(d)	5 values in 3 years	Not listed	na	Listed
Pollutants with Human Health-based Standards	Number of Exceedances →	≤ 1	na	≥ 2
305(b)	5 values in 3 years	Not assessed for 305(b)	na	Not assessed for 305(b)
303(d)	5 values in 3 years	Not listed	na	Listed
Conventional Pollutants and Water Quality Characteristics	Percent Exceedance →	< 10 %	10 – 25 %	> 25 %
305(b)	10 values in 10 years	Fully supporting	Partially supporting	Not supporting
303(d)	10 values in 10 years	Not listed	Listed	Listed
Fecal Coliform, Step 1 200 orgs./100 ml	Percent Exceedance →	< 10 %	≥ 10 %	na
305(b)	10 values in 10 years	Fully supporting	Step 2	na
303(d)	10 values in 10 years	Not listed	Step 2	na
Fecal Coliform, Step 2 200 orgs./100 ml	Number of months with Exceedances → (geometric mean)	No months	1 or 2 months	> 2 months
305(b)	Geometric mean of 5 values over 10 years for each month	Full supporting	Partially supporting	Not supporting
303(d)	Geometric mean of 5 values over 10 years for each month	Not listed	Listed	Listed
Fecal Coliform, Step 2 2000 orgs./100 ml	Percent Exceedance →	< 10 %	10 – 25 %	> 25 %
305(b)	10 values in 10 years	Full supporting	Partially supporting	Not supporting
303(d)	10 values in 10 years	Not listed	Listed	Listed

* Values are individual or single data points. Exceedance thresholds are of individual values unless noted otherwise.

na = not applicable. There is no "partially supporting" or "review" category for toxics and fish tissue contaminants, no "not supporting" or "listed" category for step 1 of fecal coliform assessments, and no specific minimum data requirements for biological and fish tissue contaminant assessments.

Table 18. Summary of Data Needed for Water Quality Assessments for 305(b) Report and 303(d) List for Use Support and Impairment Determinations, for Pollutants with Narrative Standards.

Pollutant Category **305 (b) Report, or 303(d) List**	**Minimum Number of Values*, and Data Treatment**	**Exceedance Thresholds:** • **Eutrophication Guideline values** • **IBI Scores** • **Contaminant Levels in Fish Tissue** **Use Support or Listing Category**		
Eutrophication (lakes) Northern Lakes and Forests Ecoregion	Total phosphorus →	< 30 µg/L	30 – 35 µg/L	> 35 µg/L
	Chlorophyll-a →	< 10 µg/L	10 – 12 µg/L	> 12 µg/L
	Secchi disk →	≥ 1.6 meters	1.6 – 1.4 meters	< 1.4 meters
305(b)	1 total phosphorus, chlorophyll-a or Secchi disk	Full supporting	Partially supporting	Potentially Not supporting to Not supporting
303(d)	12 total phosphorus, 12 chlorophyll-a and 12 Secchi disk	Not listed	Review, to determine to list or not list	Listed
Eutrophication (lakes) North Central Hardwood Forests Ecoregion	Total phosphorus →	< 40 µg/L	40 – 45 µg/L	> 45 µg/L
	Chlorophyll-a →	< 15 µg/L	15 – 18 µg/L	> 18 µg/L
	Secchi disk →	≥ 1.2 meters	1.2 – 1.1 meters	< 1.1 meters
305(b)	1 total phosphorus, chlorophyll-a or Secchi disk	Full supporting	Partially supporting	Potentially Not supporting to Not supporting
303(d)	12 total phosphorus, 12 chlorophyll-a and 12 Secchi disk	Not listed	Review, to determine to list or not list	Listed
Eutrophication (lakes) Northern Glaciated Plains and Western Corn Belt Plains Ecoregions	Total phosphorus →	< 70 µg/L	70 – 90 µg/L	> 90 µg/L
	Chlorophyll-a →	< 24 µg/L	24 – 32 µg/L	> 32 µg/L
	Secchi disk →	≥ 1.0 meters	1.0 – 0.7 meters	< 0.7 meters
305(b)	1 total phosphorus, chlorophyll-a or Secchi disk	Full supporting	Partially supporting	Potentially Not supporting to Not supporting
303(d)	12 total phosphorus, 12 chlorophyll-a and 12 Secchi disk	Not listed	Review, to determine to list or not list	Listed

* Values are individual or single data points. Exceedance thresholds are of individual values unless noted otherwise.

** Assessment of mercury fish tissue data not limited to most recent 10 years.

na = not applicable. There is no "partially supporting" or "review" category for toxics and fish tissue contaminants, no "not supporting" or "listed" category for step 1 of fecal coliform assessments, and no specific minimum data requirements for biological and fish tissue contaminant assessments.

Table 18. continued

Pollutant Category **305 (b) Report, or 303(d) List**	**Minimum Number of Values*, and Data Treatment**	**Exceedance Thresholds:** • **IBI Scores** • **Contaminant Levels in Fish Tissue** **Use Support or Listing Category**		
Biological Community (fish)	IBI score → (old method)	Excellent, good or fair	na	Poor or very poor
	IBI score → (new method)	IBI ≥ basin-specific threshold IBI	Discrepant results within stream segment	IBI < basin-specific threshold IBI
305(b)	See Section IX.B.	Fully supporting	Partially supporting	Not supporting
303(d)	See Section IX.B.	Not listed	Listed	Listed
Fish Tissue Contaminants**	Tissue concentration →	≤ 0.2 ppm Hg or PCBs	na	> 0.2 ppm Hg or PCBs
305(b)	Waterbodies with fish consumption advice	Information	na	Information
303(d)	mean concentration, by lake by species by size, over most recent 5-year period having data	Not listed	na	Listed

* Values are individual or single data points. Exceedance thresholds are of individual values unless noted otherwise.

** Assessment of mercury fish tissue data not limited to most recent 10 years.

na = not applicable. There is no "partially supporting" or "review" category for toxics and fish tissue contaminants, no "not supporting" or "listed" category for step 1 of fecal coliform assessments, and no specific minimum data requirements for biological and fish tissue contaminant assessments.

Developing Conclusions for Non-305b Assessments

These assessments are more complex, since they don't necessarily have established benchmarks or methodology.

For Biological Data Assessment of Biological Condition

Here's an example of how conclusions can be drawn using a percent similarity index:

> Percent Similarity: This is the similarity of the assessment site to the reference condition. Developing a finding about what the resulting percentage means usually involves some sort of guidance. For example, here's a guideline that could be used to evaluate the percent similarity for benthic macroinvertebrates:

- **>79% Non-impaired:** Comparable to the best situation expected within an ecoregion. Good representation of pollution intolerant organisms. Optimum community structure compared with reference.
- **29-72% Moderately Impaired:** Partly comparable to the best situation expected within an ecoregion. Community structure shows decrease in richness and pollution intolerant organisms.
- **<21% Severely Impaired:** Not comparable to the best situation expected within an ecoregion. Low richness, dominated by few families.

Of course, since this is not a 305b assessment, the word "impaired" might need to be changed

For Lake Trophic Status Assessment Based on Carlson's Trophic State Index

Lakes are commonly classified according to the Carlson's Trophic State Index. The index is a quantitative scale ranging from 0 to 100 scale or 100 tropic levels. There are three separate indexes. One for total phosphorus, one chlorophyll *a,* and one for water transparency as measured with a Secchi disk. Formulas used to calculate them are in the Carlson's Trophic State discussion in the Lake Info tab of the Reference Material notebook. The scale is divided into four categories.

- **TSI = 0 – 40 Oligotrophic** These are nutrient poor, usually clear, low algae production lakes and are commonly found in northeastern Minnesota. Many mountain and crater lakes also fall into this category.
- **TSI = 40-50 Mesotrophic** These are moderately productive lakes
- **TSI = 50-70 Eutrophic** These are nutrient rich with high levels of algae productivity. Algal growth often results in murky green water.
- **TSI > 70 Hyper-eutrophic** These are very nutrient rich with heavy algal bloom possible throughout the sum, dense macrophyte beds, but their extent is limited by light penetration.

General Questions to Develop Conclusions

Aside from the comparisons (formal or informal) to some sort of benchmarks, there are some very basic questions that can give you insight into your watershed.

- What might explain the changes over time?
- What might explain the changes over space?
- What might explain your results?
- Where are the high quality waters that should be protected?

How do quality control results compare with expected results:

- How will the sensitivity of the methods and equipment you used affect the results?
- What is the degree of change that is important for each parameter, considering natural baseline and variability?

List the form your conclusions will take (see sidebar for some examples). Will they be a list of the use-support status for each site, or will you try to determine causes? For lakes, will you characterize the trophic status?

Examples of Conclusions

- Drainage from the farm barnyard appears to be causing elevated fecal coliform levels in the tributary stream in an estuary. The consistently high levels of fecal coliform at site X occur mostly during low flow in the feeder brook. This suggests a continuous source of fecal material entering the stream near this site. These bacteria are most likely causing the beaches to remain closed.
- The elevated phosphate levels at site Y, compared with sites X and Z, are causing impacts to the stream in the forms of excessive algal growth and reduced benthic macroinvertebrate diversity. We believe that fertilizers from the golf course may be the cause.
- Erosion from a construction site upstream of site Z appears to be causing excessive sediment deposition in the stream, resulting in the filling in of cobble habitats, deep sediment deposits in pools, and lower abundance of benthic macroinvertebrates (especially the scraper critters which require clean rock surfaces) compared with a site immediately upstream.
- The benthic macroinvertebrate community at site 3 is impaired based on low richness and dominance by pollution-tolerant taxa. The cause is likely a combination of heavy embeddedness by sediment from the construction of the Happy Acres residential development and phosphorus in runoff from the Drivin' Me Crazy Driving Range.
- The beach on the north shore of South Lake is a health risk for swimming, based on high bacteria levels, apparently caused by nearby failing on-site sewage systems.

List Quality Control Questions you will ask about your data to determine if it can support your findings and conclusions.

In addition to assessing the water body, you also must assess your quality control data. Look at your quality control results. How often did you meet your data quality goals? This is important to know, so that you can determine if your data is useable.

- Did you collect the required number of samples from the minimum number of sites (completeness)?
- Did you collect samples frequently enough, at the right time of year, at the right time of day to be representative of the conditions you are assessing (representativeness)?
- How did your quality assurance results (from split, duplicate, spiked, replicate, known, unknown, and blank samples) compare with expected results? Did they meet your data quality objectives?
- Do the field notes coincide with the data, (i.e. cold temps, rainfall,)?
- Are there any transcription errors?

After these comparisons are made, the conclusions are drawn. These conclusions relate back to your monitoring question(s). There are

State Water Quality Assessments (305b)

This process (under section 305b of the Clean Water Act) draws conclusions about whether waters support their designated uses. The indicators are compared with the criteria in the water quality standards (see above) and, depending on the results of that comparison, a conclusion is drawn as to whether conditions support designated uses (usually water recreation and aquatic life).

Question: Do streams support designated uses?

Yes: Fully Supporting - designated uses attained and supported

Partly: Partial Support

- fish and aquatic life is present, but depressed
- violations of water quality standards found, but < 25% of the results
- fish community supported, but fish flesh is contaminated by toxics)

No: Not Supporting - uses not supported

- Chemical: For any parameter, if 10% of collected samples (>25% if less than 24 samples) violate criterion
- Bacteria: Single Violation
- Benthic Macroinvertebrates: Field assessment using informal criteria and best professional judgement
- Habitat: Field assessment using informal criteria and best professional judgment

Use CO example

This process (under section 305b of the Clean Water Act) draws conclusions about whether waters support their designated uses. The indicators are compared with the criteria in the water quality

standards (see above) and, depending on the results of that comparison, a conclusion is drawn as to whether conditions support designated uses (usually water recreation and aquatic life).

Changes Over Time

- For multiple years of data, what are some overall trends?
- Did the time of day you sampled affect your results?
- For episodic discharges, did your sampling coincide with the discharge?

Changes Over Space

- For example, ponds and wetlands can influence river bacteria levels and stream creatures just downstream.
- Is there an overall pattern upstream to downstream?
- is there a difference between bays and the main lake?
- Are conditions different above and below pollution sources?

Examples of Conclusions

- Drainage from the farm barnyard appears to be causing elevated fecal coliform levels in the tributary stream in an estuary. The consistently high levels of fecal coliform at site X occur mostly during low flow in the feeder brook. This suggests a continuous source of fecal material entering the stream near this site. These bacteria are most likely causing the shellfish beds to remain closed.
- The elevated phosphate levels at site Y, compared with sites X and Z, are causing impacts to the stream in the forms of excessive algal growth and reduced benthic macroinvertebrate diversity. We believe that fertilizers from the golf course may be the cause.
- Erosion from a construction site upstream of site Z appears to be causing excessive sediment deposition in the stream. This results in filling in of cobble habitats, deep sediment deposits in pools, and lower abundance of benthic macroinvertebrates (especially the scraper critters which require clean rock surfaces) compared with a site immediately upstream.

Draw Conclusions: What are the causes and sources of problems?

If you've determined that there are meaningful differences in your data, and that these differences indicate a problem, the next step is to develop your explanation of what might be causing the problem. This might require another look at your data in light of the following questions:

- Does weather and/or tidal stage appear to influence your results?
- If you are monitoring the impact of a pollution source, does the presence of this source explain your results?
- Might natural changes explain your results?
- Do changes in one of your indicators appear to explain changes in another?
- Could your visual observations help explain any of your results?
- Might management activities affect your results?

Draw Conclusions: Where are the high quality waters which should be protected?

If there are no meaningful differences between the results are your test sites and reference conditions, these waters that exceed your expectations. You would conclude they are ion good health.

Some Important Things To Keep In Mind When Interpreting Your Data

- the degree of trust you have in the quality of the work done to obtain the data. For the first sampling time, you might learn more about how to use the equipment and the procedures than you will about the actual water quality. Although this is excellent information about the process of science, any data that is the result of learning by trial and error should not be reported unless you are confident that the procedures were not compromised. Alternatively, you can report it if you note the sampling and/or analysis problems which may have occurred.
- the sensitivity of the methods and equipment you used. This will constrain what you can and can't say. For example, if you used a color wheel to determine orthophosphate concentration, you can't detect concentrations below 0.1 mg/l. So you shouldn't report these as "0." You should say that the results were "< 0.10 mg/l".
- the degree of change that is important for each indicator. You may be able to detect some fairly small changes in the levels of indicators. Yet, these changes may not be very important in terms of their impact on the river, estuary, or lake. Whether this change is important depends on several factors:
- how the change compares with the natural, background, or baseline levels of that indicator in your water body. If natural levels are high (compared with typical water bodies), it may take a relatively large change in conditions to impair ecological processes.
- how the change compares with the natural variability of the indicator in your water body. The level of most indicators varies naturally over time and space. If the change you measure is within the range of this natural variability, it will probably not affect the waterbody.
- whether the change crosses a threshold. There are two types of thresholds that might be important:
    1. the absolute level of an indicator. If your results fall above or below this value, an impact results (such as a level that is critical for the survival of aquatic life), and
    2. the magnitude of the change. For example, a certain fish may be acclimated to the current water temperature but sensitive to changes beyond a certain range.

Case Study 1

Case Study 2

References

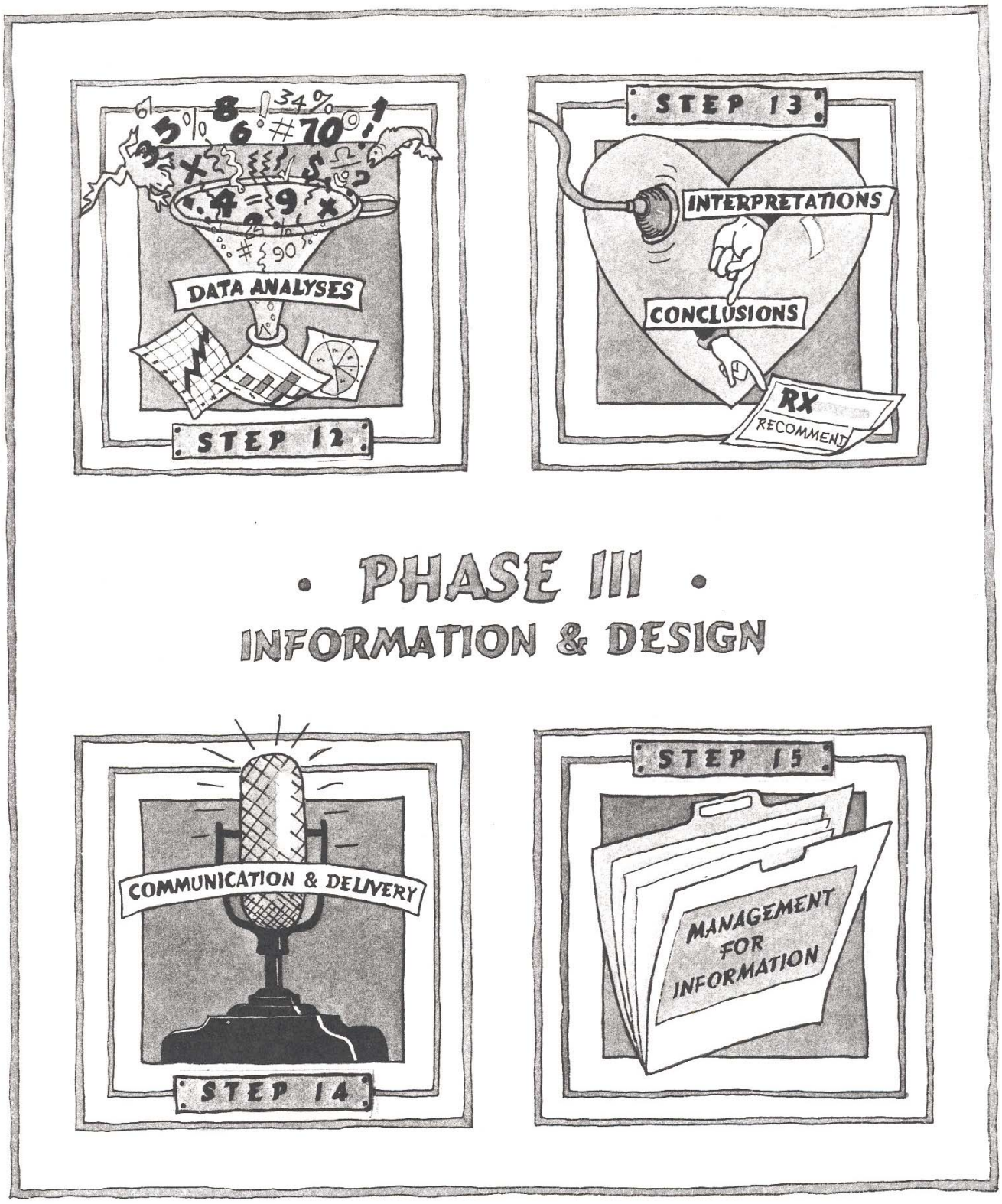
Becker Kudelka, Angie, Geoff Dates, Sandra Holm, 2004. Monitoring Plan Pilot Training Manual. Rivers Council of Minnesota, St. Cloud, MN

Dates, Geoff and Schloss, Jeff, 1998. Data To Information: A Guide Book for Coastal Volunteer Water Quality Monitoring Groups In New Hampshire and Maine. University of Maine Cooperative Extension

U.S. E.P.A. 1997. Volunteer Stream Monitoring: A Methods Manual EPA 841-B-97-003. U.S. Environmental Protection Agency, Office of Water 4503F, Washington DC.

U.S. E.P.A. 1991. Volunteer Lake Monitoring: A Methods Manual EPA 440/4-91-002. U. S. Environmental Protection Agency, Office of Water, Washington DC.

Resources



Step 14:
Communication and Delivery

"Until a person can say I am where I am because I choose to be here, a person can't say I choose otherwise."

Stephen Covey

About This Step – *This step is designed to accomplish 1 thing:*

1. Help you plan a data delivery and communication strategy for getting your data out to the people who will use it

Why Do This Step

This will be an evolving process, changing with what you learn about the watershed and with the need for information of various types as the watershed protection and/or restoration effort grows and develops.

There are multiple "off ramps" to deliver data, which could be raw data, analyzed data, interpreted data, or data reported as part of an on-going watershed program. In that case, the data would be used to give protection and management a tool to evaluate the success of the program.

This is where you turn over the information to your data users or use it yourself. Unless you haven't thought about how this might work, you may waste time and energy communicating the wrong message to the wrong audience.

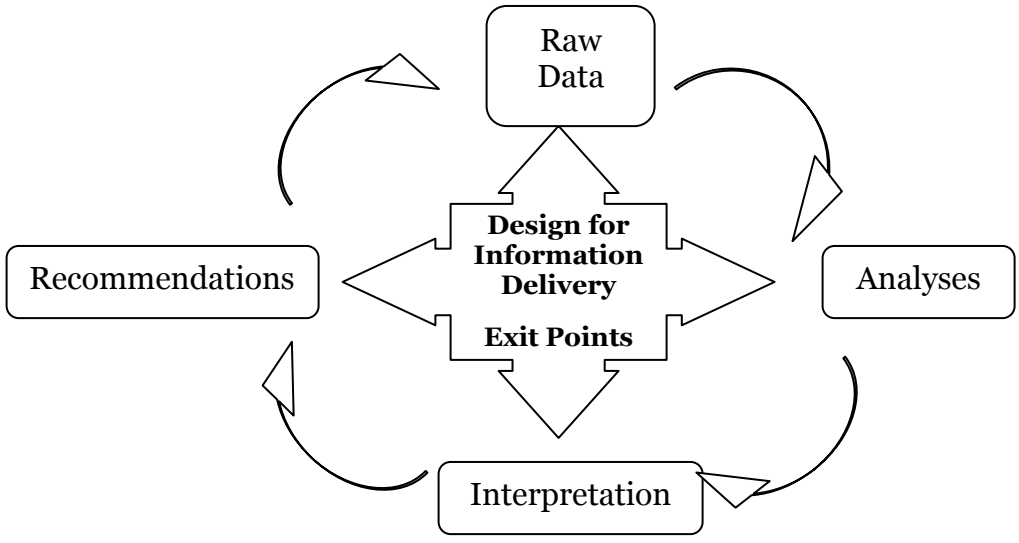
This step is about getting the information you collect, in the right form, at the right time to the right people. For example about this: you may only have 5-10 minutes to tell the story of your watershed

Where are we in the Big Picture Illustration?

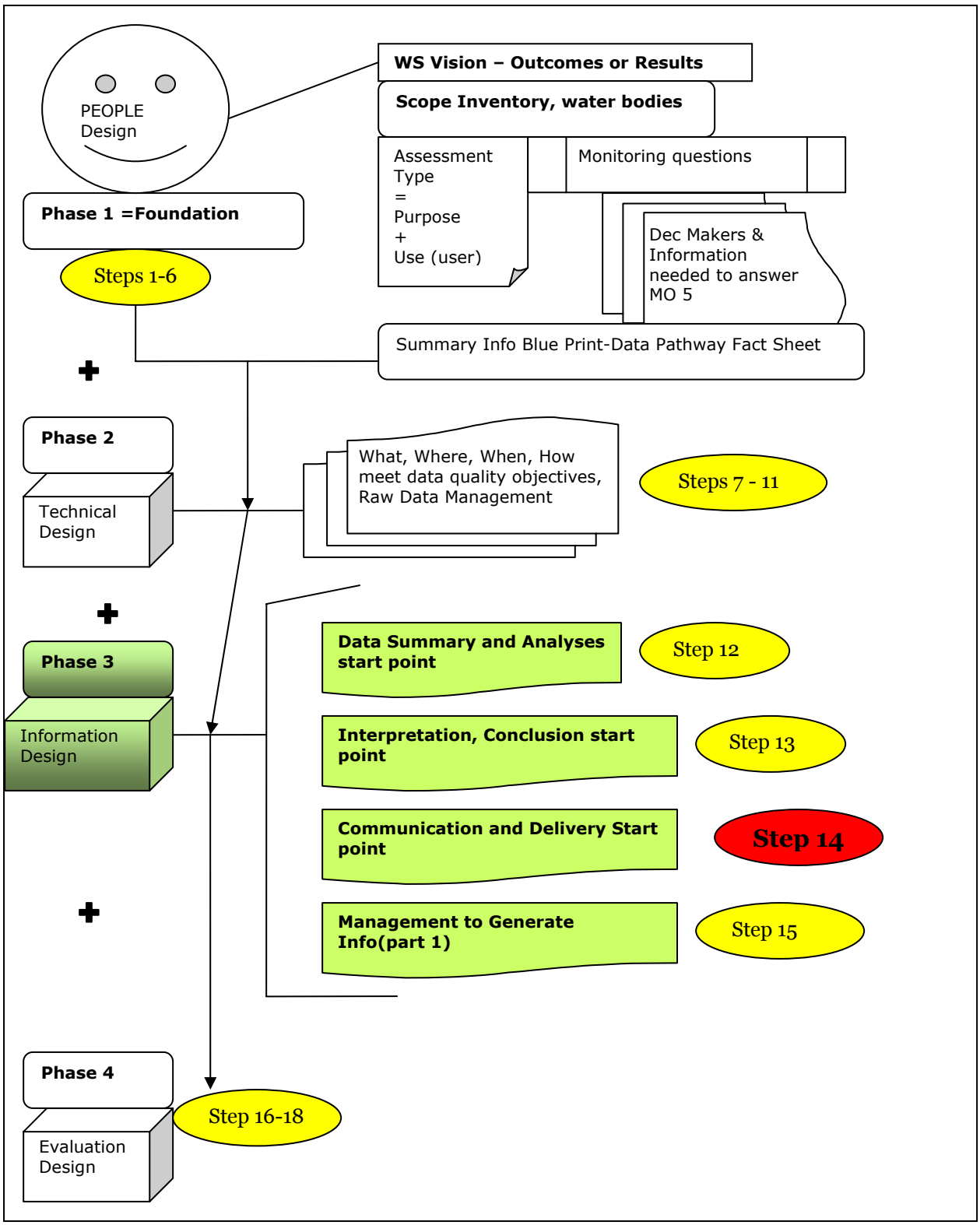
Phase 1	Step 1: Share Watershed Vision and Desired Outcomes (Results) Step 2: Scope Inventory (Physical, People and Information) Step 3: Identify Monitoring Reason(s) and Data Use(s) (Assessment Type) Step 4: Develop Monitoring Questions (Refinement of Monitoring Reason) Step 5: Target Decision Makers and Info Needs (Refinement of Data Use) Step 6: Summarize with Information Blue Print-Data Pathway Fact Sheet)
Phase 2	Step 7: What Will You Monitor? Step 8: When Will You Monitor? Step 9: Where Will You Monitor? Step 10: How Will You Monitor to Meet Data Quality Objectives? Step 11: Management of Raw Data (Data Management Plan Part 1)
Phase 3	Step 12: Data Summary and Analysis Step 13: Interpretation, Conclusions and Recommendations ➡➡➡ **Step 14: Communicating and Delivery** Step 15: Management to Generate Info (Data Management Plan Part 2)
Phase 4	Step 16: Who Will Do What? Task Identification Step 17: Evaluation of Effectiveness (of Plan and Implementation) Step 18: Documentation and Communication (of M & A Plan)

Product (see Figure Phase 3 Product List):

- ✓ A communication and delivery plan for raw data, results, data summaries and analyses, inteprettations, conclusions and recommendations, depending upon what will meet the information needs of each of your decision makers. There are several exit ramp options:



Phase 3 Product Illustration:



What Should Be Done Before This Step

The results from Phase 1 or the people orientation provides the foundation for Phase 2 Steps. Thus, ideally you need to have identified a watershed vision and desired outcomes with associated assumptions and external factors. Defined combination of monitoring reasons and uses, we call Assessment types. For each assessment type a list of monitoring questions the data is to answer and how that question will be answered.

For each monitoring question, a list of targeted decision makers, their decision, how they make that decision and what information they need to make the decision. A format to document and summarize the results, we have suggested the information blueprint. If your decision maker has a mechanism to analyze and interpret/assess the data then you have your starting point for this step, just document it. If not then this step helps you define that starting point.

The results from Phase 2 Steps, provide the foundation for Phase 3 Steps. Steps 7-9 identify indicators, characterize frequency, and identify sites that will answer monitoring questions. Step 10 identifies and documents methods, data quality objectives and quality control procedures necessary to make the desired decisions. Step 11 defines how raw data will be managed to be ready for Phase 3, turning that raw data into information to be delivered.

From Phase 3, Step 12 and 13 you have:

- ✓ An identified method for comparing your quality control data to your data quality objectives.
- ✓ Benchmarks established for each parameter
- ✓ A methodology for comparing your data to each of the benchmarks
- ✓ The statistical measures you will use to summarize the central tendency and variability of the data.
- ✓ A set of questions you will ask of your data to develop findings and conclusions.
- ✓ A starting point and plan for interpretation, conclusions and recommendations

Basic Tasks

Basic Tasks are numbered to correlate with the overall 1-18 Steps provided in these guidance modules followed by the basic task sequence step to complete. For example Step 4, basic task 2 would be numbered as Basic Task Step 4.2, Step 3.3 correlates to Step 3, Basic Task 3.

 14.1 Identify who will make the decisions about this step and who should be involved in the planning process (they may be different).

 14.2 Self Assessment: If you've been monitoring before you've undertaken this process, has your data communication about and delivery of your story been effective?

 14.3 Review the decision-makers and the decisions they make that will use your data (from step 4)

 14.4 Identify your possible target audiences (including decision-makers) for your results,

 14.5 How will you identify the essential message(s) in your story?

 14.6 How should the message be delivered? Where should the message be delivered? When should the message be delivered?

 14.7 Update *Data Management Plan Part 1*. See provided outline in Step 11, edit or develop your own for these items.

 14.8 Update *Inventory Master List* and *Plan.*

 14.9 Update *Information Blueprint – Data Pathway Fact Sheet* for each monitoring question.

 14.10 Place Products in your *Watershed Monitoring and Assessment Plan*.

 14.11 Place your identified gaps and needs regarding this step in the *Action Plan* (what you need to plan to complete this step and or overall monitoring and assessment plan).

Worksheets

Work sheets are listed below. Not all Basic Tasks have an associated work sheet. To simplify completion of products for each step, the worksheets or broken into small subsets of tasks. This requires moving the results of one task into the next task and will seem redundant, especially if completing worksheets by hand. Worksheets are provided in word here for ease of reproducibility. These are a starting point; we encourage you to customize these and reproduced them in an electronic format, in Excel for example, where it is easy to move information from one area to another by cutting and pasting.

Work Sheets are numbered to correlate with Basic Steps and the overall Steps in these guidance modules. Each consecutive work sheet is lettered a, b, c and so forth, preceded by the Basic Task sequence step, preceded by the Step number. For example, Worksheet Step 4.2.a and Step 4.2.b, correlates to Step 4, Basic Task 2, Worksheet a and Worksheet b. In theory worksheet a needs to be completed before worksheet b.

Worksheet 14.2.a	**Self Assessment Step 14 Worksheet and Products to be completed Prior to this Step, Part 1 and Part 2**
Worksheet 14.5.a	**How will you identify the essential message(s) in your story?**
Worksheet 14.6.a	**Who is the audience and what is your process for reaching them**
Worksheet 14.10.a	**Place Products in your *Watershed Monitoring and Assessment Plan.***
Worksheet 14.11.a	**Place your identified gaps and needs regarding this step in the *Action Plan* (what you need to plan to complete this step and or overall monitoring and assessment plan).**

How to Do the Worksheets

For Step 14.2.a Self Assessment Step 14 Worksheet and Products to be completed Prior to this Step, Part 1 and Part 2

Part 1. Complete the self assessment section of the worksheet to evaluate what you have or what decisions have already been made. This will help you focus on what you need from this step and incorporate valuable existing information or products into this plan.

Part 2. Next, to prepare to complete this step the following, you need to have the following items addressed:

- ✓ Desired set of outcomes or results that the monitoring and assessment activities will be designed to help achieve
- ✓ Identified monitoring and assessment activities, specific combinations of a monitoring reason plus an associated data use; we call this an Assessment Type. You may have multiple Assessment Types.
- ✓ For each Assessment Type, the list of specific monitoring questions the monitoring and assessment will be designed to answer.
- ✓ For each monitoring question, the targeted decision makers, the type of decisions they will make and the information they need to make them (as specific as possible).
- ✓ A minimal scoping inventory that identifies the watershed boundary and water bodies you are focusing on (rivers, lakes or wetlands), physical attributes of water bodies (including status, uses, etc.), relevant cultural or historical aspects, existing data sets or monitoring efforts and others in the watershed who either you want to influence or could help you implement.
- ✓ Technical sample plan including what monitor (indicators, benchmarks, criteria, etc.), where and when monitor, how will meet data quality objectives (methods, how good does the data need to be for decision makers, quality assurance and control measures), and how will manage and verify raw data/information.
- ✓ Plans for data analyses and developing findings
- ✓ Plans for interpretation, conclusions and recommendations

This is the ideal list, if you do not have any of these, they become a gap or need that should be addressed before any data is collected or analyzed, even if the answers aren't perfect or you don't have a large degree of confidence surrounding them, they should be attempted as the starting point. This is what you are evaluating in this step-your monitoring and assessment plan.

Worksheet 14.2.a Self Assessment Step 14 Worksheet and Products to be completed Prior to this Step, Part 1.

Part 1 Self Assessment of Known Evaluation Products and Processes

1. **Determine if you "have" or "don't have" the item, mark the appropriate box. If you don't have it and determine you don't need it, explain why in the comments document. You may not need to know but perhaps your target decision makers, board or membership might want to know.**

2. **If you have the item "documented", mark that box. If so, list in the comments where, hard copy, chapter in a document, electronic file name and location, etc. The assumption is you value the ultimate goal to document and communicate your M & A plan, activities and results.**

3. **If you have the item, assess the use of it, use the scale below or provide your own answer and comments.**

Rating Scale for USE:

0=doesn't exist so use is nil
1=don't know why would need or understand item
2=exists, don't know where it is, if it is used, etc. so use is essentially nil
3=exists and use some of time
4=exists and use all the time
5=wish it existed, would use it lots

Item	Have	Don't Have	DOC	Assessment of Use (Scale 0-5)	Assessment of value / effectiveness (Scale 0-4)	Comments/Notes
43. Starting point for Data communication and delivery plan, identify information exit point, what to report, when, to whom, how, and who does it.						**Phase 3 Step 14**

*DOC=Documentation, *M & A= Monitoring and Assessment

5. To make this assessment useful, determine what your gaps and needs are regarding this step in order to focus your effort in completing this step.

Worksheet 14.2.a Self Assessment Step 14 Worksheet and Products to be completed Prior to this Step, Part 2.

Part 2 Products to be completed before this step, in order to complete this step

Item	Response
Desired set of outcomes or results that the monitoring and assessment activities will be designed to help achieve:	
Assessment Types, specific combination of one monitoring reason and data use(r):	
For each Assessment Type, the list of specific monitoring questions:	
For each monitoring question, the targeted decision makers, the type of decisions they will make and the information they need to make them (as specific as possible):	
Watershed(s) and Water bodies of focus:	
Physical attributes of Water bodies (status, use, etc.)	
Existing Data or monitoring efforts:	
Indicators, benchmarks and criteria list:	
Characterization of monitoring frequency:	
List of monitoring locations/rationale:	
Methods list, list of data quality objectives (methods, how good does the data need to be for decision makers), quality assurance and control measures)	
Plan for raw data management and support mechanisms:	
Monitoring results summarized using statistics, graphs and tables.	
The results of your comparison of your data with your benchmarks summarized	
The results of your comparison of your QC data with your data quality objectives	
A method to develop a set of findings from the data set	
Plan or starting point for making interpretations, conclusions and recommendations	

Worksheet 14.5.a How will you identify the essential message(s) in your story?

Describe how you will boil your findings, conclusions, and recommendations into messages. What are the concepts you want people to take away from your story?

For Sheet 14.6.a Who is the audience and what is your process for reaching them

Audiences

Audiences go well beyond the immediate circle of people who are working on watershed conservation and restoration, from decision-makers to the general public.

- Who are they? Not everyone can be reached with one format or presentation so it's important to determine who most needs the information.
- Sometimes information alone is enough; sometimes you need to add content that educates or persuades.

Please refer to the Background Content section for more ideas on audiences.

How message will be developed

Briefly describe who will develop the essential message(s) and how they will do it. Who will be consulted.

Report Format

What reporting formats are you considering (e.g. written technical reports, slide presentations)

Where and when message will be delivered

What are the places where you can best reach your audience. For presentations, its usually more effective if you go to them: annual meetings, board meetings, and other regularly scheduled events where you are reasonably sure you'll have an audience.

Worksheet 14.6.a Who is the audience and what is your process for reaching them

Audiences	How message will be developed	How the Message Will be Reported, e.g. written technical reports, slide presentations	Where and when message will be delivered

For Step 14.10.a **Place Products in your** *Watershed Monitoring and Assessment Plan*.

- A plan to communicate and deliver information to each targeted decision maker, whether that is the raw data, data summary and analysis, interpretations, conclusions and or recommendations.

Worksheet 14.10.a **Add products of Step to** *Monitoring and Assessment Plan.*

If you completed any Steps this Worksheet is cumulative, use that document. If you have not you complete that aspect that is highlighted for your plan documentation. **Italics mean a sub plan that might be attached or live somewhere else, location of document and contact is what would go in the plan.*

I. People Design, Phase 1

A. Shared Watershed Vision and Desired Outcomes (Step 1)

1. Logic Model of Desired Outcomes/Results and activities/target audiences to employ to achieve outcomes

B. Keepers of the M & A Plan (Step 1)

C. Watershed Boundary (Step 2)

D. Water bodies of Interest (Step 2)

E. Scope Inventory Master List* (Step 2)

1. Physical Inventory * (Step 2)
2. People Inventory* (Step 2)
3. Information Inventory* (Step 2)
    a. Existing Monitoring Efforts (Step 2)
    b. Existing Data Sources (Step 2)
4. Inventory Action Plan* (Step 2)

F. Assessment Type(s) List – Monitoring Reason + Use (Step 3)

1. Monitoring Question(s) (Step 4)
2. Targeted Decision Maker(s) (Step 5)
    a. Information Needs (Step 5)
3. Information Blue Print – Data Pathway Fact Sheet Per Monitoring Question* (Step 6)

II. Technical Design, Phase 2

A. What (Indicators, Benchmarks, etc.) and why? (Step 7)

B. When and why? (Step 8)

C. Where and why? (Step 9)

D. W(how) will meet data quality objectives? (Step 10)

1. Data quality objectives (Step 5 and 10)

2. Quality Assurance and Control Measures (Quality Assurance and Control Plan)* (Step 10)

E. Data Management for Raw Data (Data Management Plan Part 1)* (Step 11)

III. Information Design, Phase 3

A. Data Summary and Analyses (Step 12)

1. Starting Point (Step 12)

2. Changes (Later)

B. Data Interpretation, Conclusions, Recommendations

1. Starting Point (Step 13)

2. Changes (Later)

C. Communication and Delivery

1. Starting Point (Step 14)

2. Changes (Later)

D. Management Plans to Generate Information (Data Management Plan Part 2)* (Step 15)

IV. Evaluation Design, Phase 4

A. Who Will Do What? (Step 16)

1. Task Identification Matrix (Step 16)

2. Communication Structure and Tools (Step 16)

B. Evaluation Plans (Step 17)

1. Evaluation Plans for M & A Components (Step 17)

2. Evaluation Plans for M & A Implementation (Step 17)

3. Evaluation of inter/intra M & A Activities (Step 17)

C. Documentation and Communication (Step 18)

1. M & A Plan (**this document**, updated Sub documents) (Step 18)

2. Communication and Peer Review Plan (Step 18)

3. Action Plan* (Step 17)

For Sheet 14.11.a **Place your identified gaps and needs regarding this step in the *Action Plan* (what you need to plan to complete this step and or overall monitoring and assessment plan).**

Worksheet 14.11.a **Final *Action Plan* Part 1, Summary:**

If you have completed each Step, or for those you have, you have a cumulated list of gaps and needs related to that Step. Use that same worksheet/document. If you did not complete each Step, look at what each Step is supposed to accomplish and record what your gaps and needs are related to that topic. The goals are to get the gaps and needs in one place to evaluate and prioritize.

Phase 1 Step 1: : (completed in Step 1)
Phase 1 Step 2: : (completed in Step 2)
Phase 1 Step 3: : (completed in Step 3)
Phase 1 Step 4: : (completed in Step 4)
Phase 1 Step 5: : (completed in Step 5)
Phase 1 Step 6: : (completed in Step 6)
Phase 2 Step 7: : (completed in Step 7)
Phase 2 Step 8: : (completed in Step 8)
Phase 2 Step 9: : (completed in Step 9)
Phase 2 Step 10: : (completed in Step 10)
Phase 2 Step 11: : (completed in Step 11)
Phase 3 Step 12: : (completed in Step 12)
Phase 3 Step 13: : (completed in Step 13)
Phase 3 Step 14: Communication and Delivery:
Phase 4 Steps: Will add Action and Needs as complete each Step and at the end prioritize

Background Content

Once you've converted your raw numbers into an interesting story, there are many ways to tell it: through video, written reports, press releases, oral presentations, Web Sites, posters, or other materials. At the very least, however, we recommend that you produce a written report that summarizes your work and the results. This is the basic foundation for all your presentations.

Producing A Basic Written Report

Your report should summarize your monitoring activities and results, state your findings and conclusions, and make recommendations for actions to address problems or, if needed, for changes to your sampling program, if needed. Some programs produce an annual "state of the watershed" report that summarizes and analyzes the results of the preceding year, and all previous years, highlighting trends, clean-up progress, new trouble spots, etc.

Remember that the style, length, and content of your report should be geared to the audience you are addressing. However, we recommend the following generic report format that can be adapted to different audiences:

I **Executive Summary:** Briefly describes the project and major findings, conclusions, and recommendations. Try to keep this section as non-technical and to the point as possible so it may be used and distributed separately from the report as well as incorporated into newsletters, fundraising, and other materials. (Note: this should be written last)

II **Introduction:** brief description of the geographic area and your program (including maps)

III **Project Description**: briefly describe your study design:

- A Questions you tried to answer/hypotheses you tried to prove
- B Water Quality Indicators Monitored
- C Sampling and Analytical Methodology
- D Location Where Samples Were Collected and Analyzed
- E Time When Samples Were Collected and Analyzed
- F Quality Assurance Procedures

IV **Results**

- A How Were the Data Analyzed?
- B Findings
- C Conclusions
- D Recommendations

V **Acknowledgments**

VI **References**

VII **Appendices**: Some tables and graphs generated for your data exploration need not have been used in the body of the report if they are not important to the "story" you are emphasizing. You may want to include this additional information in the appendices. It is also very important to include summaries of all data collected for your monitors, as well as for future reference if conditions change. Include:

- ✓ Map of Study Area
- ✓ Sampling Site List
- ✓ Data Tables
- ✓ Graphs
- ✓ Quality Assurance Data

Your written report brings your data for the season, or for several years, to completion. Now you're ready to start sampling again next season!

Communicating Within Your Program

Keep your volunteers informed of the results as often as possible. Some groups produce monthly summaries for volunteer participants or send out periodic newsletters. Remember: volunteer monitors need some feedback on how they are doing.

Communicating with Your Audience

Focusing the Message

Information is shared through data presentation efforts. Data presentation follows, and is dependent upon the scientific inquiry and policy work that was completed when your group started monitoring. That process helped you decide what to focus on, how to do it, and (later) what the results meant. Data presentations must remain consistent with your findings, conclusions and recommendations.

Target Audiences

Who are they? Not everyone can be reached with one format or presentation so it's important to determine who most needs the information.

Appropriately targeting any of these audiences involves considering their many different perspectives. People and groups within each of these audiences will have various cultural backgrounds or experiences, levels of technical expertise, objectives, and goals. The length, clarity and amount of technical detail you include greatly affect how much your audience understands and remembers. A great, easy-to-read summary of general presentation considerations can be found in the Massachusetts Water Watch Partnership's "Ready, Set, Present!" manual.

Audiences
* Community members
* Native community
* Tribal Council and other leaders
* Other Native communities and program staff
* Organizations
* Businesses
* Non-Native community (at the local, state or national level)
* Grassroots watershed protection groups
* Municipalities
* Organizations
* Businesses
* General public
* State or federal agencies (Tribal or otherwise)
* Environmental and wildlife protection
* Public health
* Resource management

How important are these people to the issue?

Are they the "movers and shakers," or less-involved characters? This can depend on the issue as well as those involved, also known as "stakeholders." Sometimes, the chain of authority is clear and direct. For instance, a Conservation Commission reviews an application for a near-shore development. In others, the impact is less direct or immediate such as when you attempt to influence landowners' lawn-care practices. Each landowner may only have a small impact, but in the aggregate, the effect on the watershed is large. There are many situations in between: you may target business groups such as auto repair shops that may or may not dump oil and grease down drains. There are also "backup" decision-makers: those to whom you turn if your primary audience is recalcitrant, (e.g. you get the state agency to overrule a bad Conservation Commission decision).

Do they need your information?

Will it change their minds? Maybe they already have enough data on a situation or are already doing the right thing. If so, try redirecting your outreach efforts to other decisionmakers who still need convincing.

Tip:
If an audience is hard to reach, consider working through an intermediary. For example, farmers and Conservation Districts (CDs) work together a lot. Try approaching the CD to arrange a meeting with the local farmers to discuss their fertilization practices.

What do they need besides information?

Efforts sometimes have to be focused on education or persuading people to take the right course. Generally, you decide who to target first, then decide how to approach them. Consider the how a bit now though, to get an idea of how much effort you should devote to a potential data user.

How can they be reached?

Is your relationship with them friendly, or adversarial? This is another strategy consideration once a target audience is selected, but it's also a consideration in whether to go after them at all.

Sometimes information alone is enough; sometimes you need to add content that educates or persuades.

Delivering the Message

Where should the message be delivered?

Find the right places and media that will put the audience in a data receptive mood.

How will the message be delivered?

Technical report presentations or dinner talks? Which information products and delivery strategies will best deliver the message?

Varying the technical level of your story can be one of the most difficult aspects of presenting monitoring information and telling your story - you can never reach everyone. An additional challenge can be the translation of technical information from a western perspective into a culturally relevant format for Native communities. For example, state and federal agencies might require a technical scientific report for their information. Even if your audience is familiar with all of the technical details of your work, not everyone wants or has the time to deal with a lot of information. So you might want to summarize that information into a less detailed format for tribal council or community members.

Now that you've decided with whom you want to share your data, think about the audience and finding the best way to communicate with them. Before people can make good decisions that protect or restore a watershed, they should know:

1. A little watershed ecology: how a watershed or water body functions;
2. The condition of the subject water body or watershed;
3. What causes current conditions;
4. The sources of any pollution or related problems;
5. The consequences: how conditions affect things that people care about: the economy, fishing or swimming, etc.;
6. Solutions: steps that can be taken to improve or maintain conditions.

Basic Tools To Tell the Story

- Maps
- Graphs
- Illustrations and Paintings
- Music
- Story-telling
- Newsletters
- Written Reports
- Video
- Poster Exhibits
- Oral Presentations
- Slides

Think about the best way to communicate with the audience. Not everyone can be reached with one kind of format or presentation, so it's important to determine who most needs (and can use) the information. The length, clarity, and amount of technical detail you include greatly affect how much your audience understands and remembers.

Consider if you need different formats for different audiences. For example, state and federal agencies might require a technical scientific report for their information and use.

When Will the Message Be Delivered?

Timing. Develop and stick to reasonable timelines when planning outreach strategies.

1. Start at the very beginning: in the program planning phase. At this point, issues are articulated, questions are raised and explored, audiences with whom you will address issues are considered. Assume that you will make some recommendations, even though you can't know what they'll be yet. The point is, plan early.
2. During the course of a survey or sampling season: there isn't as much planning required at this stage if background work has been completed. Make sure the preparations are going on schedule. Take photos of sites and samplers and have the software purchased and tested. Be on the alert for unexpected results such as fish kills and extreme levels of coliforms that need immediate attention or are newsworthy. If this happens, be prepared to move fast with press releases and email alerts.
3. After the sampling season: Now is the time to review earlier presentation plans and sharpen their focus. Identify the messages such as the rivers really unhealthy don't go near the water or the lake has a healthy fish population which must be protected or plants are choking the lake, action is needed now! Will you recommend any specific actions you want taken (e.g. post signs, pass a bill)? Do your newly refined messages still match your targeted audiences? Do your planned delivery strategies (slide shows, newspaper stories, etc.) still make sense? If

there are any changes from your earlier plans, be sure to adjust the schedule and strategy accordingly.

Case Study 1

Case Study 2

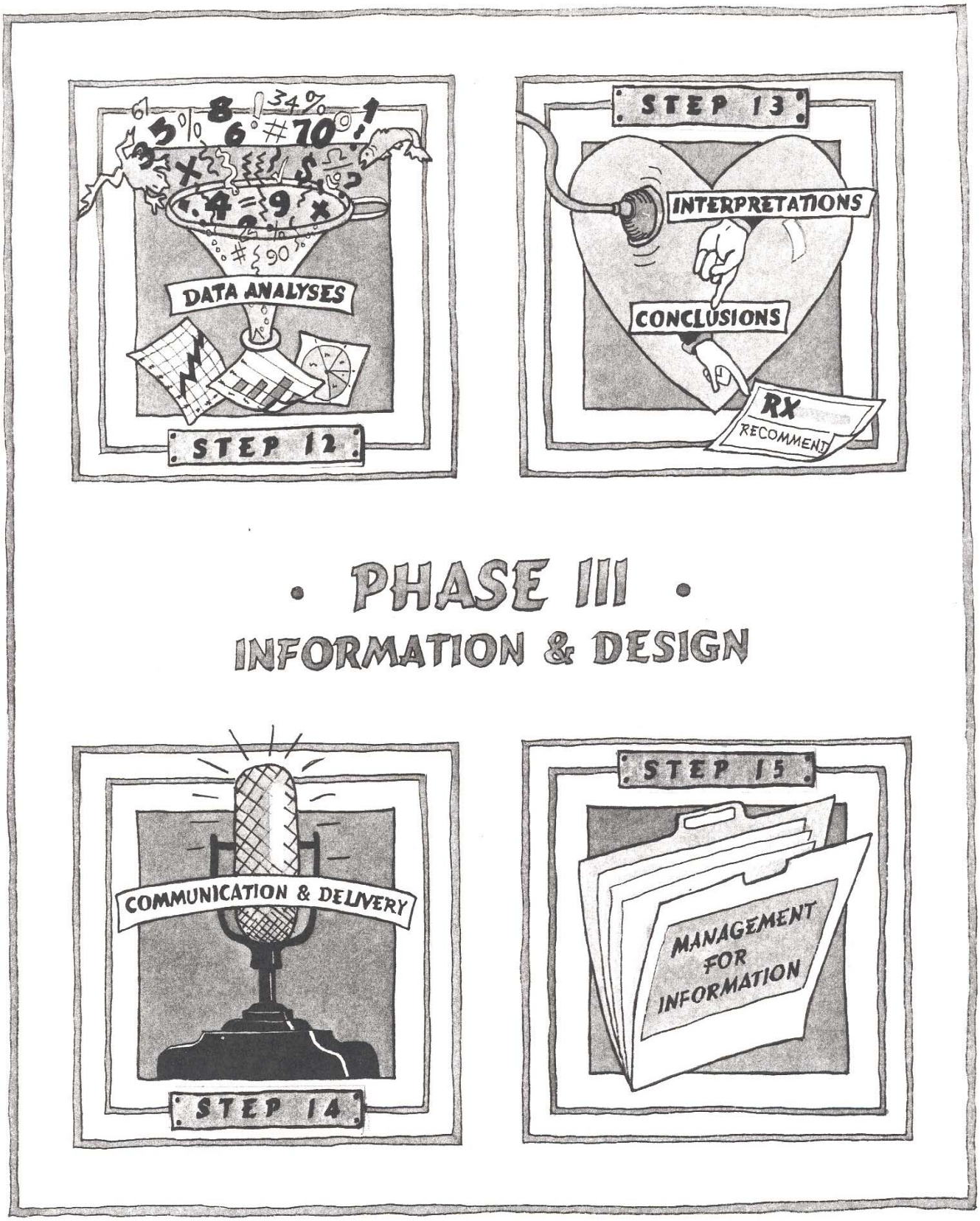
References

Dates, Geoff and Schloss, Jeff, 1998. Data To Information: A Guide Book for Coastal Volunteer Water Quality Monitoring Groups In New Hampshire and Maine. University of Maine Cooperative Extension

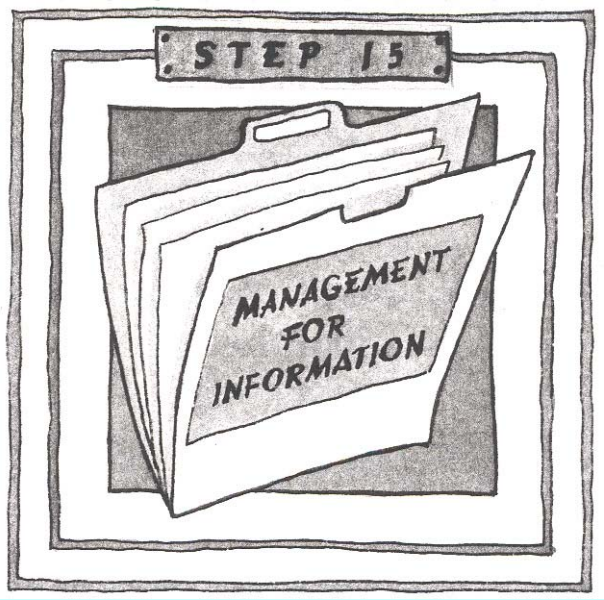
U.S. E.P.A. 1997. Volunteer Stream Monitoring: A Methods Manual EPA 841-B-97-003. U.S. Environmental Protection Agency, Office of Water 4503F, Washington DC.

U.S. E.P.A. 1991. Volunteer Lake Monitoring: A Methods Manual EPA 440/4-91-002. U. S. Environmental Protection Agency, Office of Water, Washington DC.

Resources



Step 15 Management to Generate Information (Data Management Plan Part 2)



"Many people believe that new industrial revolutions are already taking place, with the rise of cyber technology, bio and nano technology. It is true these are tools for change, but the model for the next industrial revolution may well have been right in front us the whole time….a tree."

William McDonough

About This Step – *This step is designed to accomplish 2 things:*

1. Inventory of Data Management needs for:
   - Conducting data Summaries and Analysis
   - Formulating Interpretations, Determining Conclusions and/or Making Recommendations
   - Determine Result Reporting, Communication and Delivery
2. Complete Data Management Plan Part 2, add to Data Management Plan Part 1

Why Do This Step?

We are monitoring to effect a change, so when we get the data we are usually very ready to look at it, analyze it and see if it said what we wanted or hypothesized. In some cases, we haven't even thought about how we will analyze it, cross that bridge when we get there. We assume someone will take the data and do some analyses, interpretation, make recommendations, report and use the data. How do you know this if you don't plan it from the start?

We often do not plan how we will manage the data before we collect it. This is a serious resource drain. It is equivalent to planning a dinner party, and not including in the plan the part to purchase the food, determine the cook(s), preparing the house and setting the table. If we didn't plan these items and

consequently complete them, when the guests arrive (the data is collected), we scurry about and try and make it happen. We might end up with a great dinner party, but it undoubtedly was a bit more stressful than it needed to be. How we plan to manage the data is essential in the ability to answer monitoring questions, deliver information to our decision makers, evaluate the success or failure, meet the goals of our assessment type and associate outcomes that manifest our watershed vision. Yes, we can get by without it, but it always costs more in time and money.

It can be frustrating to identify how you plan to analyze, interpret and report data, for example if your comfort level or experience is lacking confidence or if your decision makers either don't know these answers, won't share with you or you are breaking new ground. It is the hardest part of monitoring and assessment. It is the messiest. It is an iterative process as well.

We are suggesting that is imperative to define a starting point with what you do know. If we know how our decision makers conduct their own data analyses, interpretation, reporting and manage the data for those functions, then it is simple. We mimic those process and data management. If we do not know we get resourceful, asking others what they do or what they would do. We might be able to borrow or mimic from other processes and data management systems that deal with similar data or processes. You might need to get creative and figure out what your decision makers do and how. You may need to get even more creative and define it for the decision maker. We may even have to develop something new and try it. Develop something and have the decision maker review it. We must plan the starting point with the best available information about where we want to end.

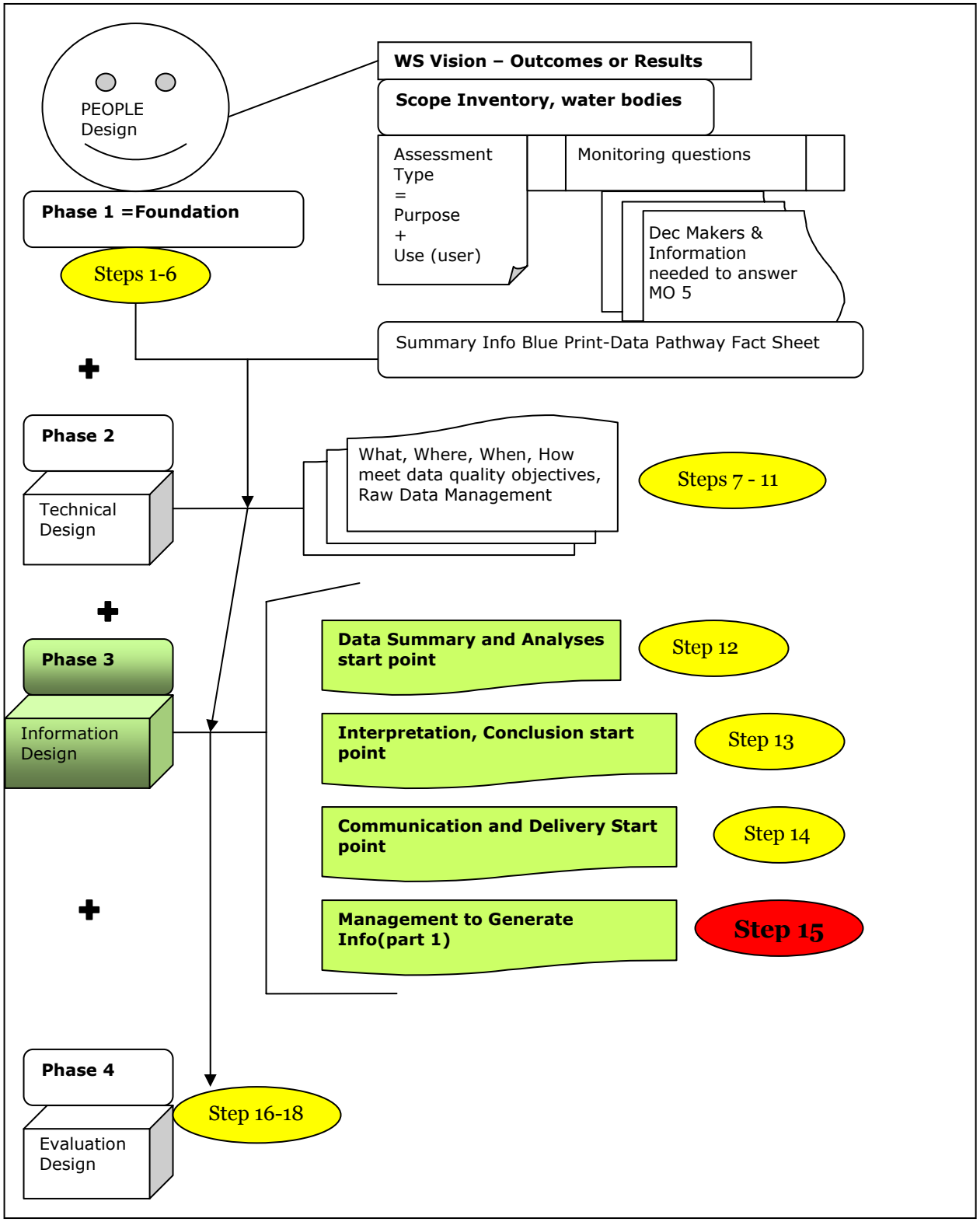
Where are we in the Big Picture Illustration?

Phase 1	Step 1: Share Watershed Vision and Desired Outcomes (Results) Step 2: Scope Inventory (Physical, People and Information) Step 3: Identify Monitoring Reason(s) and Data Use(s) (Assessment Type) Step 4: Develop Monitoring Questions (Refinement of Monitoring Reason) Step 5: Target Decision Makers and Info Needs (Refinement of Data Use) Step 6: Summarize with Information Blue Print-Data Pathway Fact Sheet)
Phase 2	Step 7: What Will You Monitor? Step 8: When Will You Monitor? Step 9: Where Will You Monitor? Step 10: How Will You Monitor to Meet Data Quality Objectives? Step 11: Management of Raw Data (Data Management Plan Part 1)
Phase 3	Step 12: Data Summary and Analysis Step 13: Interpretation, Conclusions and Recommendations Step 14: Communicating and Delivery ➡ **Step 15: Management to Generate Info (Data Management Plan Part 2)**
Phase 4	Step 16: Who Will Do What? Task Identification Step 17: Evaluation of Effectiveness (of Plan and Implementation) Step 18: Documentation and Communication (of M & A Plan)

Product (see Figure Phase 3 Product List):

- ✓ An inventory of support needs for the functions of data summary/analyses, formulating interpretations and conclusions, making recommendations, and reporting, communication and delivery of the results to targeted decision makers (products of Phase 3), determination of how you will retrieve and manipulate raw data through these functions and maintain integrity.
- ✓ A final Data Management Plan, Part 1 (results) and Part 2 (transformation of results to information and delivery),

Phase 3 Product Illustration:



What Should Be Done Before This Step

The results from Phase 1 or the people orientation provides the foundation for Phase 2 Steps. Thus, ideally you need to have identified a watershed vision and desired outcomes with associated assumptions and external factors. Defined combination of monitoring reasons and uses, we call Assessment types. For each assessment type a list of monitoring questions the data is to answer and how that question will be answered. For each monitoring question, a list of targeted decision makers, their decision, how they make that decision and what information they need to make the decision. A format to document and summarize the results, we have suggested the information blueprint.

The results from Phase 2 provide the foundation for Phase 3 Steps. This includes the monitoring design, the what, when, where, how and quality assurance and control plan for generating data/results.

Finally, the results from Phase 3 to this point should be identified. The first Step in Phase 3, Step 11 Part A, results in a list of what data and meta-data you are generating that needs managing, a decision on what minimum information you will require through out managing the data, and an illustration of how data will travel through the various processes. Part B, takes the first cut at identifying system support decisions, such as database design, data result relationships with meta-data, hardware/software decisions, graphics, GIS/Web considerations, naming conventions, miscellaneous thorns to consider, user considerations, process tools and safety measures.

Steps 12-15 in Phase 3 are designed to help you determine specifically what processes and tools you plan to start with in order to turn results into information through analyses, interpretation, making recommendations and reporting. In theory, these were first identified in Phase 1, as you selected targeted decision makers and tried to determine their information needs, including how and what they needed for the above functions.

This step, Step 15, is once the data-to-information processes, tools are identified, the data management needs of these processes can be identified. This leads to developing Part 2 of the Data Management Plan, management for turning results (Data Management Plan 1) into information for delivery and utilization.

Basic Tasks

Basic Tasks are numbered to correlate with the overall 1-18 Steps provided in these guidance modules followed by the basic task sequence step to complete. For example Step 4, basic task 2 would be numbered as Basic Task Step 4.2, Step 3.3 correlates to Step 3, Basic Task 3.

 15.1 Identify who will make the decisions about this step and who should be involved in the planning process (they may be different).

 15.2 Self Assessment: Identify what decisions have been made and their effectiveness.

 15.3 For each monitoring question identify the starting point, inventory the data-to-information functions, all activities and functions you need to complete, then determine data management needs to support (retrieval, manipulation, maintain integrity and support decisions).

 15.4 Diagram or illustrate the steps from data storage, through summary, analysis, interpretation, conclusion, recommendation and delivery functions. Complete the diagram from Step 11, Part A, if it is useful.

 15.5 Summarize decisions, this is the *Data Management Plan Part 2,* add information to *Data Management Plan Part 1* for completion and you have a documented data management plan. See outline provided in Phase 2, Step 11, Worksheet $$ 11.X.a. See the proposed content in the Background and Content Section.

 15.6 Update *Inventory Master List* and *Plan.*

 15.7 Update *Information Blueprint – Data Pathway Fact Sheet* for each monitoring question

 15.8 Place Products in your *Watershed Monitoring and Assessment Plan*.

 15.9 Place your identified gaps and needs regarding this step in the *Action Plan* (what you need to plan to complete this step and or overall monitoring and assessment plan).

Worksheets

Work sheets are listed below. Not all Basic Tasks have an associated work sheet. To simplify completion of products for each step, the worksheets or broken into small subsets of tasks. This requires moving the results of one task into the next task and will seem redundant, especially if completing worksheets by hand. Worksheets are provided in word here for ease of reproducibility. These are a starting point, we encourage you to customize these and reproduced them in an electronic format, in Excel for example, where it is easy to move information from one area to another by cutting and pasting.

Work Sheets are numbered to correlate with Basic Steps and the overall Steps in these guidance modules. Each consecutive work sheet is lettered a, b, c and so forth , preceded by the Basic Task sequence step, preceded by the Step number. For example, Worksheet Step 4.2.a and Step 4.2.b, correlates to Step 4, Basic Task 2, Worksheet a and Worksheet b. In theory worksheet a needs to be completed before worksheet b.

Worksheet 15.2.a	**Self Assessment Step 15 Worksheet and Products to be completed Prior to this Step, Part 1 and Part 1**
Worksheet 15.3.a	**For each monitoring question identify the starting point, inventory the data-to-information functions, all activities and functions you need to complete, then determine data management needs to support (retrieval, manipulation, maintain integrity and support decisions)**
Worksheet 15.4.a	**Illustrate how each monitoring question and associated data will travel from data storage through the data-to-information functions management system. Add to diagram from Step 11, Part A, if valuable.**
Worksheet 15.8.a	**Add products of Step to** *Monitoring and Assessment Plan*
Worksheet 15.9.a	**Place your identified gaps and needs regarding this step in the** *Action Plan* **(what you need to plan to complete this step and or overall monitoring and assessment plan)**

How to do Worksheets

For Step 15.2.a Self Assessment Step 15 Worksheet and Products to be completed Prior to this Step, Part 1

Part 1. Complete the self assessment section of the worksheet to evaluate what you have or what decisions have already been made. This will help you focus on what you need from this step and incorporate valuable existing information or products into this plan.

Part 2. Next, to prepare to complete this step the following, you need to have the following items addressed:

- ✓ Desired set of outcomes or results that the monitoring and assessment activities will be designed to help achieve
- ✓ Identified monitoring and assessment activities, specific combinations of a monitoring reason plus an associated data use; we call this an Assessment Type. You may have multiple Assessment Types.
- ✓ For each Assessment Type, the list of specific monitoring questions the monitoring and assessment will be designed to answer.
- ✓ For each monitoring question, the targeted decision makers, the type of decisions they will make and the information they need to make them (as specific as possible).
- ✓ A minimal scoping inventory that identifies the watershed boundary and water bodies you are focusing on (rivers, lakes or wetlands), physical attributes of water bodies (including status, uses, etc.), relevant cultural or historical aspects, existing data sets or monitoring efforts and others in the watershed who either you want to influence or could help you implement.
- ✓ Technical sample plan including what monitor (indicators, benchmarks, criteria, etc.), where and when monitor, how will meet data quality objectives (methods, how good does the data need to be for decision makers, quality assurance and control measures), and how will manage and verify raw data/information.
- ✓ Plans for data analyses and developing findings
- ✓ Plans for interpretation, conclusions and recommendations
- ✓ Plans for communicating and delivering raw data, data summaries or analysis, interpretation, conclusions or recommendations to each targeted decision maker according to their information needs.

This is the ideal list, if you do not have any of these, they become a gap or need that should be addressed before any data is collected or analyzed, even if the answers aren't perfect or you don't have a large degree of confidence surrounding them, they should be attempted as the starting point. This is what you are evaluating in this step-your monitoring and assessment plan.

Worksheet 15.2.a Self Assessment Step 15 Worksheet and Products to be completed Prior to this Step, Part 1.

Part 1 Self Assessment of Known Evaluation Products and Processes

1. **Determine if you "have" or "don't have" the item, mark the appropriate box. If you don't have it and determine you don't need it, explain why in the comments document. You may not need to know but perhaps your target decision makers, board or membership might want to know.**

2. **If you have the item "documented", mark that box. If so, list in the comments where, hard copy, chapter in a document, electronic file name and location, etc. The assumption is you value the ultimate goal to document and communicate your M & A plan, activities and results.**

3. **If you have the item, assess the use of it, use the scale below or provide your own answer and comments.**

   Rating Scale for USE:
   0=doesn't exist so use is nil
   1=don't know why would need or understand item
   2=exists, don't know where it is, if it is used, etc. so use is essentially nil
   3=exists and use some of time
   4=exists and use all the time
   5=wish it existed, would use it lots

4. **If you have the item, assess the effectiveness of it, just because something exists or is used does not mean it is effective in its use, use the effectiveness scale below or provide your own answer and comments.**

   Rating Scale for EFFECTIVENESS, assumes material exists:
   0=not effective or functional at all
   1=incomplete (all elements are not there) and some existing parts need revising
   2=incomplete but what is there is okay
   3=complete (all elements are there), some parts okay but need revising
   4=complete and effective

Item	Have	Don't Have	DOC	Assessment of Use (Scale 0-5)	Assessment of Value / Effectiveness (Scale 0-4)	Comments
44. How will data be managed to support generation of information functions and retain integrity plan?						
OTHER?						

*DOC=Documentation, *M & A= Monitoring and Assessment

5. To make this assessment useful, determine what your gaps and needs are regarding this step in order to focus your effort in completing this step.

Worksheet 15.2.a Self Assessment Step 15 Worksheet and Products to be completed Prior to this Step, Part 2.

Part 2 Products to be completed before this step, in order to complete this step

Item	Response
Desired set of outcomes or results that the monitoring and assessment activities will be designed to help achieve:	
Assessment Types, specific combination of one monitoring reason and data use(r):	
For each Assessment Type, the list of specific monitoring questions:	
For each monitoring question, the targeted decision makers, the type of decisions they will make and the information they need to make them (as specific as possible):	
Watershed(s) and Water bodies of focus:	
Physical attributes of water bodies (status, use, etc.)	
Existing Data or monitoring efforts:	
Indicators, benchmarks and criteria list:	
List of monitoring locations/rationale:	
List of monitoring frequencies:	
Methods list, list of data quality objectives (methods, how good does the data need to be for decision makers), quality assurance and control measures)	
Plan for raw data management and support mechanisms:	
Monitoring results summarized using statistics, graphs and tables.	
The results of your comparison of your data with your benchmarks summarized	
The results of your comparison of your QC data with your data quality objectives	
A method to develop a set of findings from the data set	
Plan or starting point for making interpretations, conclusions and recommendations	
Plan to communicate and deliver appropriate information to each targeted decision maker	

For Sheet 15.3.a **For each monitoring question identify the starting point, inventory the data-to-information functions, all activities and functions you need to complete, then determine data management needs to support (retrieval, manipulation, maintain integrity and support decisions).**

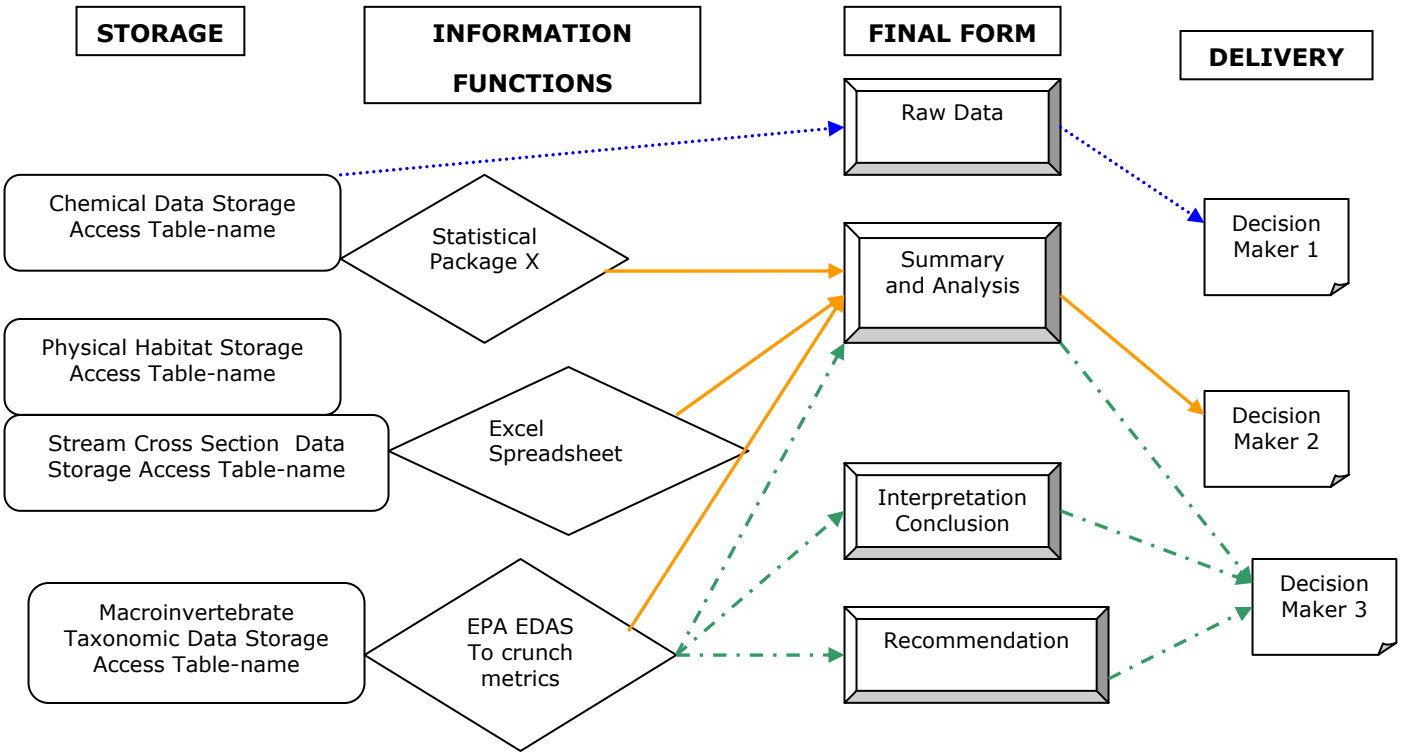
Worksheet 15.3.a Data-to-information management needs inventory per monitoring question.

Review the functions of data summary and analysis (Step 12, interpretation, conclusion and recommendations (Step 13), communication and delivery (Step 14) and articulate management needs. The goal is to understand how data will be retrieved from storage place, manipulated in a way that maintains data integrity and ends up in a format that serves decision maker. Refer to Products of Steps 11-14 and edit worksheet to meet your needs.

Assessment Type:	
Monitoring Question:	
Decision Maker 1 Management Needs for:	**Decision Maker 2 Management Needs for:**
Summary & Analysis:	Summary & Analysis:
Int, Conc, & Recommd:	Int, Conc, & Recommd:
Communicate & Delivery:	Communicate & Delivery:
Decision Maker 3 Management Needs for:	**Decision Maker 4 Management Needs for:**
Summary & Analysis:	Summary & Analysis:
Int, Conc, & Recommd:	Int, Conc, & Recommd:
Communicate & Delivery:	Communicate & Delivery:
Decision Maker 5 Management Needs for:	**Decision Maker 6 Management Needs for:**
Summary & Analysis:	Summary & Analysis:
Int, Conc, & Recommd:	Int, Conc, & Recommd:
Communicate & Delivery:	Communicate & Delivery:

Worksheet 16. 7.a **Illustrate how each monitoring question and associated data will travel from data storage through the data-to-information functions management system. Add to diagram from Step 11, Part A, if valuable.**

See the following example of how you might illustrate this. The benefit is to help communicate how the transition occurs, through what and who is responsible. Here the Blue dotted decision maker wants raw chemical data, thus the information support is just around providing raw chemical data, support might be an automated excel spreadsheet. The Orange solid decision maker wants chemical, physical and biological data, summary and analysis, no interpretation/conclusion or recommendations. The Green dashed decision maker wants macroinvertebrate data only, but the summary, analysis, interpretation, conclusion and recommendations. How will I take data from storage, through the functions, into a delivery format? What support mechanisms to I need (software, hardware, time, training, GIS, web, etc.)? Diagram your system if it is useful.



For Sheet 15.8.a **Add products of Step to** *Monitoring and Assessment Plan.*

- Data management Plan Part 1 and 2 additions to support management for information generation

Worksheet 15.8.a **Add products of Step to** *Monitoring and Assessment Plan.*

If you completed any Steps this Worksheet is cumulative, use that document. If you have not you complete that aspect that is highlighted for your plan documentation. **Italics mean a sub plan that might be attached or live somewhere else, location of document and contact is what would go in the plan.*

I. People Design, Phase 1

   A. Shared Watershed Vision and Desired Outcomes (Step 1)

      1. Logic Model of Desired Outcomes/Results and activities/target audiences to employ to achieve outcomes

   B. Keepers of the M & A Plan (Step 1)

   C. Watershed Boundary (Step 2)

   D. Water bodies of Interest (Step 2)

   E. Scope Inventory Master List* (Step 2)

      1. Physical Inventory * (Step 2)
      2. People Inventory* (Step 2)
      3. Information Inventory* (Step 2)
         a. Existing Monitoring Efforts (Step 2)
         b. Existing Data Sources (Step 2)
      4. Inventory Action Plan* (Step 2)

   F. Assessment Type(s) List – Monitoring Reason + Use (Step 3)

      1. Monitoring Question(s) (Step 4)
      2. Targeted Decision Maker(s) (Step 5)
         a. Information Needs (Step 5)
      3. Information Blue Print – Data Pathway Fact Sheet Per Monitoring Question* (Step 6), including Cost Estimate

II. Technical Design, Phase 2

   A. What (Indicators, Benchmarks, etc.) and why? (Step 7)

   B. When and why? (Step 8)

   C. Where and why? (Step 9)

   D. W(how) will meet data quality objectives? (Step 10)

1. Data quality objectives (Step 5 and 10)
2. Quality Assurance and Control Measures (Quality Assurance and Control Plan)* (Step 10)

E. Data Management for Raw Data (Data Management Plan Part 1)* (Step 11)

III. Information Design, Phase 3

A. Data Analyses (Step 12)
   1. Starting Point (Step 12)
   2. Changes (Later)

B. Data Interpretation, Conclusions, Recommendations
   1. Starting Point (Step 13)
   2. Changes (Later)

C. Communication and Delivery
   1. Starting Point (Step 14)
   2. Changes (Later)

D. Management Plans to Generate Information (Data Management Plan Part 2)* (Step 15)

IV. Evaluation Design, Phase 4

A. Who Will Do What? (Step 16)
   1. Task Identification Matrix (Step 16)
   2. Communication Structure and Tools (Step 16)

B. Evaluation Plans (Step 17)
   1. Evaluation Plans for M & A Components (Step 17)
   2. Evaluation Plans for M & A Implementation (Step 17)
   3. Evaluation of inter/intra M & A Activities (Step 17)

C. Documentation and Communication (Step 18)
   1. M & A Plan (**this document**, updated Sub documents) (Step 18)
   2. Communication and Peer Review Plan (Step 18)
   3. Action Plan* (Step 17)

For Step 15.9.a **Place your identified gaps and needs regarding this step in the Action Plan (what you need to plan to complete this step and or overall monitoring and assessment plan).**

Worksheet 15.9.a **Final Action Plan Part 1, Summary:**

If you have completed each Step, or for those you have, you have a cumulated list of gaps and needs related to that Step. Use that same worksheet/document. If you did not complete each Step, look at what each Step is supposed to accomplish and record what your gaps and needs are related to that topic. The goals is to get the gaps and needs in one place to evaluate and prioritize.

Phase 1 Step 1: (completed in Step 1)
Phase 1 Step 2: (completed in Step 2)
Phase 1 Step 3: (completed in Step 3)
Phase 1 Step 4: (completed in Step 4)
Phase 1 Step 5: (completed in Step 5)
Phase 1 Step 6: (completed in Step 6)
Phase 2 Step 7: (completed in Step 7)
Phase 2 Step 8: (completed in Step 8)
Phase 2 Step 9: (completed in Step 9)
Phase 2 Step 10: (completed in Step 10)
Phase 2 Step 11: (completed in Step 11)
Phase 3 Step 12: (completed in Step 12)
Phase 3 Step 13: (completed in Step 13)
Phase 3 Step 14: (completed in Step 14)
Phase 3 Step 15, Management to Generate Information (Data Management Plan Part 2):
Phase 4 Steps: Will add Action and Needs as complete each Step and at the end prioritize

Background and Content

The goal of this step is to determine what design components, tools and processes your data management system needs in order to support the functions that turn data/results into information. The process of turning data/results in to information includes the activities of analyses, interpretation, reporting and data/information delivery to the target decision maker. Thus, the first step is to identify what your starting points are for these functions. This was determined in Steps 12-15.

It is possible that you provide the decision maker raw data, they conduct analyses, do interpretation and give you their conclusion. In that case, you pick up the conclusion and decide what you will do with the information. In that case plan the data management system to support functions from that point on. In other cases you are responsible for and doing analyses, interpretation and making recommendations, you need to plan for these functions and for the data base management system support.

Assessment

What are you doing now and what do you need to do?

Who should be involved?

In the determination of what you plan as a starting point for data analyses, interpretation and reporting/delivery, you have the opportunity to involve each targeted decision maker, peers, other experts, stakeholders and other interested or knowledgeable individuals. If you plan your data management you create the opportunity to integrate and involve more people. Managing the data, which really means the system we create to store and retrieve results, transform those results into information and deliver to our data users for our desired decision. Typically this process takes more than one person. Watershed assessment and monitoring design planners, steering committees, technical advisors all should have a vision and plan what will be done with the data in order for the data to have an end point, all before collection begins. Have the end in mind, and a defined data management path that that the data can travel on to on its journey or data pathway from planning to decision to evaluation.

Starting point for data summary and analysis

For every logical grouping of data, list the various data analyses that will be performed.

Then list the possible data management tools and processes that might be available or conducted to support these functions, both electronic and otherwise. Evaluate this against what you know today about your targeted decision makers analytical needs.

For example, the continuum from storage, retrieval, information functions delivery points:

- Chemical data – validation – Access Chem Table – Summary statistics with package X – Annual Watershed Report-Delivery to Website, EPA STORET, Dept of Health Basin Reviews, upon request

Contrast with:

- Chemical data – validation – Excel Spreadsheet, Summary Statistics in Excel-monthly report on conditions-to Park Service Beach Posting

I can elaborate on the Summary and Analysis per monitoring question, listing specific indicators for example.

The activities or functions in data analyses usually include the task of summarizing the data with simple statistics, advance statistics, creating tables and graphs or ways to view the data and qualifying the data from analyzing quality assurance and control results. Another task in this step often includes being able to compare data. Compare data from different sites, impacted to reference, upstream/downstream, before/after, or results against certain criteria, and the like. How best is the data stored to conduct these functions?

It is not uncommon to store your data in one place and move it to another to do these functions. To pull from a central place and conduct all external type functions. There are some advantages to that, including maintaining data integrity. Data is not entered twice for example. Depending upon the ease of transfer and associated manipulations, it may not be efficient. For example, if analyses is mapped or connected to the main database, then as the data is updated the analyses can be easily updated. If they are not coupled, then it may be cumbersome to track changes in the data over in analyses. Many software packages are designed to do specific functions, such as statistics or graphing. Some try and do it all and depending on the data size, might to just fine.

Starting point for data interpretation, recommendations

For every logical grouping of data and associated analyses, follow through and list the starting point for how interpretation will be conducted and who will be involved.

Then list the possible data management tools and processes that might be available or conducted to support this function, both electronic and otherwise. Evaluate this against what you know today about your targeted decision makers interpretation needs.

The activities and functions here take data summaries, analyses and findings and interpret them. This may or may not involve more criteria, lumping or summaries. But usually involves some standard manner of saying you have answered your monitoring questions, or your interpretation of that. In defining your monitoring questions you completed the sentence, “My monitoring question A is met when XYX”. You attempted to define XYZ in Step 5 and 6. Through analyses you generate results and through interpretation you decide if you did or did not answer the objective, and why. The why, becomes your conclusions.

You may not need any data management to support your interpretation or conclusions or you may. You may need to put your interpretations in some format for making recommendations and reporting, but that is the next steps. You may find that you need to make more tables or graphs or the like to in order to illustrate your recommendations. It is hard to know what each recommendation or action will be and thus plan your data management, it is an iterative process. The key here is to have a plan for what you do know and a place holder for when you do get here. You need to manage your data to some degree to get to this point in the process. For each monitoring question you have defined the XYZ, "Monitoring question A is met when XYZ", thus what will you recommend today if XYZ is true? Is false?

Make a list of your interpretation and recommendation functions and then ask what software will work the best to meet those needs while maintaining an interface with where the data is stored, where it is analyzed, interpreted and will need to travel next.

Starting point for data reporting, delivery and utilization

The minimum "action" you will take is to deliver your data, results and information to your targeted decision maker. We call this reporting and data utilization. For every logical grouping of data, associated analyses and resulting interpretation, follow through and identify how that information will reported to each targeted decision maker. The list of what will be provided should include everything in Step 5 or on the information blueprint from Step 6.

Then list the possible data management tools and processes that might be available or conducted to support this function, both electronic and otherwise.

Examples of tools might be:

- Software like spreadsheet, graphing, statistics, GIS, mapping, scanning photo's, models, etc.
- Hardware might be computer related, camera, etc.
- Time
- Training
- Process policy, processes, forms, etc. for example a policy that all data is retrieved and rests in different place for information functions that is stored to maintain integrity

In Step 5 you made an attempt to discover for each monitoring question and associated targeted decision maker, the answer to their information needs. In this Step, we are suggesting you identify and answer for every step as a starting point, even if your comfort level around that decision is not high, document that as well. This will be the starting point from which you will evolve, add, and change according to trial and error, new information and evolution of the process and knowledge base. For example, the information to be reported, from the decision makers perspective needs to address:

1. **What** specifically does each decision maker need?
    - Key processes, natural/political that need to be included?
    - Key indicators?
    - Where do they need it from (key locations, political, historical, etc.)?
    - Benchmarks and references they use or need?

- What frequency/duration (length of record) does information need to be?
- How "good" does it have to be (peer reviewed, certain methods, etc.) be?
- What acceptance/performance criteria do they use, data quality objectives?
- How conduct analyses, metrics, indexes, statistics, graphics, programs, they use or need etc.?
- How conduct interpretation (thresholds, criteria, benchmarks, methods, etc.?)
- How do they either report this data/information themselves or how do they need it reported

2. **How** is the decision is made?
   - (Process), how formal, legal, rigorous, opportunities, etc.?
3. **When** do they need the information reported?
4. At what **frequency** do they need it reported?
5. **Who** will **provide it** and **how** provided? (mail, oral presentation at meeting, hearing, etc.)
6. **How** does it need to be **provided**, specific reporting format (electronic, legal, etc.)?
7. **What information** needs to be **included** in reporting format?

From the answers to the above questions, conduct an assessment of the type of information you need to include in the data management system, possible tools and processes available to you. This includes software, hardware, expertise, training, timing and even further validation. You may use different software for all of these processes than you utilize to store your data (Data Management Part1). Consider how data will travel to and through the processes of analyses to interpretation to reporting. These interfaces can be simple or complex and the success might depend on how much you plan. Don't be afraid to ask, this planet is not short on computer technicians.

Complete the data management Diagram

From Step 11, add the detail to the illustration or diagram that shows how data moves through the data management system from generation, validation, entry, storage, retrieval (Part 1) on to analyses, interpretation, reporting and data utilization. See the example provided on the worksheet.

Produce part 2 of plan to manage monitoring results?

Add to Part 1 of the Data Management Plan. To summarize, Part 1, Section A & B:

Part 1, Section A - What managing how?

1. Have an inventory of what data/results and meta-data you are generating that needs managing, including the needs of your decision makers. This may or may not result in a minimum data elements list that you require or recommend that accompany this set all the way through data management to support the processes of analyses, interpretation, reporting and delivery of information to targeted decision makers.

2. Illustration of how data will flow through the major data management processes of entry, validation, storage, retrieval for analyses, interpretation, reporting and delivery. Where, what evaluation will occur and who is responsible. How will move data through the data management system,—more after Steps 12-15 in this Phase 3.

Part 1, Section B - Data Management System Support Decisions:

1. Database Design and identified relationships
2. Hardware and software status and needs, including graphics, GIS and Web interface needs

Identified and documented naming and numbering conventions, miscellaneous thorns (detection limit, etc.), user considerations, process tools, safety measures, archive protocols, and training plan

Thus, Part 2 includes:

1. Description of data management to support starting point for data summary and analyses, who and how data will managed through analyses and interface with data storage and next step (use flow charts, tables, lists and other tools to describe)
2. Description of data management to support starting point for analyses to transform into interpretation and conclusions, who and how data will managed through interpretation and interface with data storage, analyses and next step (use flow charts, tables, lists and other tools to describe)
3. Description of data management to support starting point for interpretations to become recommendations and planned action, who and how data will managed through recommendation and interface with data storage, analyses, interpretation and next step (use flow charts, tables, lists and other tools to describe)
4. Description of data management to support starting point for interpretations and recommendations to be reported, delivered and utilized, who and how data will managed through reporting and interface with data storage, analyses, interpretation, recommendations. (use flow charts, tables, lists and other tools to describe)
5. Identified tools and processes to support the above functions, including hard ware, soft ware, access to technology and expertise, etc. combined with evaluation of what tools have/need.
6. Decision of what tools will use and why, document
7. Additions and detail added to the flow path of data through the data functions that turn data into information and deliver it.
8. Any additions, deletions or edits to Part 1 necessary to align management of results (Part 1) with data management needs to turn data/results into information (Part2)
9. Add this information to Data Management Plan Part 1 and you have a documented data management plan

Case Study 1:

Case Study 2:

References

Resources

Contents in Phase 3*, Step 15 Resource Guide*:

Closure of Phase 3 / Transition to Phase 4

What you potentially accomplished:

You defined the starting point for turning data generated into information. This includes how you plan to summarize and analyze the data, how you will interpret the analysis, formalize conclusions and develop recommendations. These starting points incorporate the information needs of your targeted decision makers for each assessment type and set of monitoring questions. There are different "off ramps" possible for decision makers. Some might desire raw data, others some degree of data summary and analyses, others might want your interpretation and conclusions and still others may need you to provide recommendations.

Next you determined the details of reporting and delivery of the "information" to each decision. This includes the details of how, when, format and who will deliver the information. The final accomplishment for this phase is identifying the management tools needed to provide the decision maker "off ramps", this may include software, hardware and processes to ensure data integrity remains while supporting these information generation functions.

What you potentially produced:

- ✓ starting point (what you know now) for data summary and analysis plans
- ✓ starting point (what you know now) to interpret, formulate conclusions and develop recommendations
- ✓ starting point (what you know now) about which off ramp (raw data, summarized, analyzed, interpreted, conclusions and/or recommendations) for each decision maker information reporting and delivery
- ✓ Management plans to generate information, completion of *Data Management Plan, Part 2*, add to *Data Management Plan Part 1*
- ✓ Additions to *Monitoring and Assessment Plan, Action Plan* and other relevant documents

Where will you go from here?

- ✓ the evaluation design, Phase 4, how you will identify who is responsible for all parts of the monitoring and assessment plan, how you will evaluate this plan, implementation of this plan, each monitoring question and Assessment Type, how you can align multiple Assessment Types within your organization or watershed, and finally how you will document and communicate your plans.